THE ENGINEER

MAY 7, 1954

Institution of Electrical Engineers

AT a meeting of the Institution of Electrical Engineers on Thursday, April 29th, Mr. J. A. Ratcliffe delivered the forty-fifth Kelvin Lecture, his subject being "The Physics of the Ionosphere." Mr. Ratcliffe reminded his audience that some thirty years had elapsed since the existence of the ionosphere had been demonstrated. In those thirty years a great deal had been discovered about the behaviour of the ionosphere, particularly in relation to its effect on radio transmission. But, he said, there was still much to be learned about the physics of the ionosphere and he showed, with the help of some spectacular demonstrations a few of the directions in which the frontiers of knowledge might usefully be extended. Before the delivery of the Kelvin lecture two awards of the Institution of Electrical Engineers were presented by the president, Mr. H. Bishop. The certificate of honorary membership was prepresented to Mr. Ernest Leete for his services to the Institution: in particular for his work as honorary treasurer and as an ordinary member of council for nearly a quarter of a century, and for his work on behalf of the benevolent fund of the Institution. The president later presented the Faraday Medal to Mr. Isaac Schoenberg for his distinguished work in electrical engineering: in particular for his outstanding contributions to the development of high definition television in this country. In his citation the president recalled that from about 1930 Mr. Schoenberg led a team of engineers and scientists who worked on the problems of developing a television service which would be suitable for public service; and that Mr. Schoenberg's development of the electronic picture tube, known as the "Emitron," contributed more, perhaps, than any other single item to the success of the new system. This system, with its ancillary equipment, was used by the British Broadcasting Corporation at the opening of the world's first public television service in November, 1936, and was adopted for exclusive use in this service in February, 1937.

Institution of Civil Engineers

THE Institution of Civil Engineers held its annual dinner on April 29th at the Dorchester Hotel, London. Mr. D. Mowat Watson was in the chair, in the absence of the president, Mr. W. P. Shepherd-Barron, who was representing the Institution at the opening of the Owen Falls dam in Uganda and was thus unable to be present. The toast of "The Institution" was proposed by Sir John Maud, Secretary of the Ministry of Fuel and Power. Sir John made a felicitous speech prior to his proposal of that toast, during the course of which he dwelt upon the importance of the civil engineer's contribution to the welfare of the community, and upon the importance of the conservation of our natural resources. Mr. D. M. Watson replied on behalf of the Institution, and noted with satisfaction that the membership of the Institution was increasing, and, in particular, there was an increase in the proportion of younger members. The Institution owed a great debt to Mr. Graham Clark, Mr. Watson continued, who had worked in the Institution's service for forty years, seventeen of them as its secretary. The toast of "The Guests" was proposed by Mr. H. F. Cronin, and the Very Rev. A. C. Don, Dean of Westminster, responded.

National Industrial Fuel Efficiency Service

THE National Industrial Fuel Efficiency Service began its operations under new organisation on May 1st. Most of the engineering staff in the former fuel efficiency branch of the Ministry of Fuel and Power has been transferred to the new organisation, the headquarters of which are at 71, Grosvenor Street, London, W.1. Sir Leslie Hollinghurst, chairman of the board of the National Industrial Fuel Efficiency Service (N.I.F.E.S.) has emphasised that his organisation will collaborate with other bodies which are aiming to improve industrial fuel efficiency. He said that the N.I.F.E.S. had been formed to give greater latitude for the development of what was already a going concern. The Ministry of Fuel and Power was turning over to N.I.F.E.S. the mobile testing units which had been used to measure the consumption of steam throughout a factory and to trace losses to their sources. The surveys made by these testing units, Sir Leslie explained, would be made available to industry at the same charge as the Ministry had made. General advice on fuel efficiency had been provided free by the Ministry, he added, and here again there was to be no immediate change. Sir Leslie pointed out, however, that a considerable development in the scale of operations would only be possible if the Service was able to earn revenue to supplement the financial support it was receiving from the fuel industries. He went on to say that all the work carried out by the N.I.F.E.S. would be on a confidential basis, and that publication of the results, either in whole or in part, would not be considered without the approval of the firms concerned. At the same time it was hoped that firms would generally consent to make known the savings in fuel that had been achieved.

Institute of Metals

ON Wednesday evening of last week, the Institute of Metals held a dinner at Grosvenor House, London, in honour of the president, members and ladies of the Société Francaise de Métallurgie, who were visiting this country to participate in the Institute's spring meetings. The president of the Institute of Metals, Dr. S. F. Dorey, F.R.S., was in the chair, and he was supported by the president of the Société Francaise de Métallurgie, Dr. E.-L. Dupuy. A toast to "The Institute of Metals and the Non-Ferrous Metal Industries" was proposed by the Joint Parliamentary Under-Secretary of State for Foreign Affairs, Mr. A. D. Dodds-Parker, who made appropriate reference to the fiftieth anniversary of the Entente Cordiale. He spoke also of the significant developments in metallurgical science which had occurred since the formation of the Institute of Metals in 1908. In responding to the toast, Dr. Dorey said that he was glad to have the opportunity to pay a tribute to the French scientists and metallurgists who had co-operated with the British in metallurgical developments of many kinds. He went on to comment on the Institute's international character, pointing out that 25 per cent of its membership came from countries overseas. Finally, Dr. Dorey said that the future success of this country depended upon scientific development, and emphasised the need for engineers, metallurgists and physicists to work closely together in order to find the proper industrial uses for nuclear energy. The toast of "The Guests" was proposed by Dr. C. J. Smithells and was graciously acknowledged by Dr. Dupuy.

Institute of Fuel Annual Luncheon

THE annual luncheon of the Institute of Fuel was held on Thursday, April 29th, in the Connaught Rooms, Great Queen Street, London, and was attended by nearly 700 members and their guests, with Dr. W. Idris Jones, the president, in the chair. Immediately following the loyal toast, the president announced that the Melchett Medal for 1954 had been awarded to Dr. H. H. Storch, of the United States Bureau of Mines, for his work on problems concerning obtaining oil from coal. Dr. Storch was presented with the medal and briefly replied. The president proposed the toast of "The Guests," and particularly welcomed the Honorable W. Walton Butterworth, Minister of the United States Embassy. During the course of his remarks he commented that British economy was facing a long-term problem and stressed the need for the maximum efficiency in the use of fuel. Sir Christopher Hinton, Deputy Controller of Atomic Energy, responded to the toast and mentioned that the common bond was interest in fuel or the carrying out of chemical reactions to produce useful heat. Nuclear reactions also released heat and Sir Christopher felt that the main difference between chemical and nuclear reactions was that when burning conventional fuel the chemical reactions took place easily, whereas nuclear reactions were more difficult to initiate and were outside the common experience of man. Fissionable materials, he continued, were just as much fuels as hydro-carbons and, therefore, came into the category of alternative fuels and, as such, should be of interest to the Institute, since coal reserves were estimated to be exhausted in 200 years. Coal was a source of many chemical raw materials and he felt that it should not be burnt under boiler, but rather nuclear, fuel. Sir Christopher likened the problems involved to those which confronted Newcomen and Watt and went on to say that the prospects for industrial power were promising. Although unit cost of nuclear power was high, capital charges formed the largest charge, and he was sure that within a comparatively short period this factor would be considerably reduced to bring nuclear powers cost to a competitive level, especially since the cost of coal was likely to rise.

Road Research Laboratory Open Days

DURING this week, the Materials and Construction Division of the Road Research Laboratory is holding open days, during which its work will be seen by many highway engineers, chairmen of highway committees of local authorities, and others concerned with the administration and construction of roads. The open days have been organised as a result of recent recommendations of the Select Committee on Estimates. The Committee stated that "the work of the laboratory is so valuable that every effort should be made to avoid the risk of its being wasted by not being known," and hence recommended improved methods of disseminating the knowledge acquired at the laboratory. From time to time the laboratory's work is described in these columns, and many of our readers will know something of the various topics of research recently carried out by the Materials and Construction Division. The subjects of research to be demonstrated at the open days include the polishing of roadstone and its effect on the skidding characteristics of the road surface, the quality of surface dressing (as a result of the application of the laboratory's work, a properly laid surface dressing should last at least five years), economies by using local materials, the use of soil cement in road construction, and the use of snow fences. One important aspect of the laboratory's work is that of research into "pavement" design, about which not all the facts are known. Valuable results were achieved in the laboratories' full-scale trials at Oxton, Nottinghamshire. Further full-scale investigation is needed, however, particularly of concrete construction on a clay formation and the select committee emphasised the importance of the proposed Alconbury Hill experiments on the Great North Road near Huntingdon, which, it is to be hoped, will be carried out in the near future.

Owen Falls Hydro-Electric Scheme

No. II—(*Concluded from page 630, April 30th*)

In the first part of this article we gave a general description of the Owen Falls scheme, and of the civil engineering works involved in its construction. Our account of the scheme is completed here with some information about its mechanical and electrical aspects.

WATER control at Owen Falls dam is effected by flood gates closing the six sluices in the centre of the dam and, at the power station, by intake gates and draught tube gates controlling the turbine culverts. It may be recalled that the six flood sluices have a maximum discharge capacity of 45,000 cusecs. A cross section through one of the sluices is shown in Fig. 10, showing some details of the gate installation. Each flood sluice is controlled by a free-roller dry-well gate, spanning 9ft 10½in and closing a depth of 16ft 8¾in. The gates are designed to sustain, and to operate against, an unbalanced head of 76ft on the sill. They are counterbalanced and electrically operated through worm and spur gearing and Renolds hoisting chain. The gates are of mild steel construction, having self-adjusting rubber seals, Meehanite reception frames and guides with naval brass sealing faces and free-roller cages. The hoisting and lowering speed is 4ft. 8in per minute,and the electrical controls may be arranged for local or remote control at the power station.

There is also one free-rolling emergency gate, of the same span and depth as the control gates, which may be used in any one of the six flood culverts. This gate is raised and lowered by a 50-ton electrically operated "Goliath" crane, which is also employed for erection and maintenance of the control gates. As may be observed from Fig. 10, the emergency gate may be stored in any of the six control gate wells. The crane operates at hoisting and traversing speeds of 7·5ft and 50ft per minute respectively, with a 50-ton load.

At each turbine intake there are two lifting screens of 14ft span and 29ft deep, hoisted by an automatic hooking beam and crane. There are also two bulkhead gates, 14ft wide by 29ft deep, designed to withstand an unbalanced head of 67ft at the sill, but to operate under balanced conditions; these gates use the same reception frames as the screens, and are lifted by the same 30-ton "Goliath" crane and hooking beam. The control gates—which are for normal operation—are housed in frames just downstream from the screens, and are free-roller dry-well gates, not unlike the control gates of the flood sluices in design and operation, but with limit switches for closing and opening. In this case, however, each gate is 21ft 3in in span and 21ft 10½in deep and controls one turbine inlet; the gates are designed to withstand and to operate against an unbalanced head of 75ft at the sill. The installation here also includes by-passes for balancing the pressure on the bulkhead gates, and indicators showing the loss of head across the screens. At the turbine draught tubes there are two sliding gates for each machine, manually operated with a gantry crane under balanced hydraulic conditions. These gates are also of mild steel, 17ft 6in by 14ft 7¾in in size, and designed to withstand a head of 38ft.

Turbines

The turbines of the principal sets at Owen Falls are vertical Kaplan machines, generally of conventional design; Fig. 12 illustrates their construction and the materials used for certain of the principal parts, and the principal data and dimensions relating to them are given in the table. The runner of each machine is five bladed and is arranged for left-hand rotation. Various stages in the installation of the sets are illustrated in Fig. 11; in the foreground draught tubes are being set in position for concreting.

Turbine Data

Gross head, metres	22
Design head, metres	19
Output, b.h.p.	21,000
Speed, r.p.m.	150
Nominal diameter of runner, millimetres	3,900
Maximum diameter of runner, millimetres	4,216
Hub diameter (machined spherical), millimetres	1,915
Angle through which blades can be turned, degrees	29
Maximum guide vane opening, millimetres	390
Specific speed, English units	123
Efficiency, per cent	91·5
Rated flow (at design head, output and efficiency as given), cusecs	3,280
Diameter of inlet of scroll casing, feet	21

A point of interest in the design of the turbines lies in the arrangement for operation as a synchronous condenser. When this is required the guide vanes are closed and compressed air is introduced from a compressor through the two pipes shown in the upper part of Fig. 12. The water level in the turbine is thus depressed clear of the runner, which can then turn in air with a consequent reduction of drag.

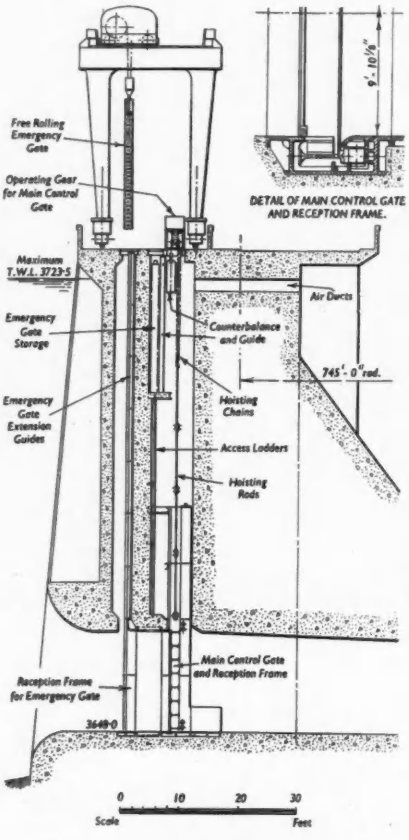


Fig. 10—Section Through Flood Culvert

The scroll casing is of mild steel and is welded at the site to a fabricated stay ring; the latter is shipped in four sections, which are also welded together at site. The runner blades are of stainless steel, and in manufacture are profile machined all over. The throat ring and runner chamber liner are also of stainless steel and the stay vanes are of cast steel, as indicated in Fig. 12.

The turbine bearing is lubricated by two motor-driven pumps, one alternating current for normal use and one direct current, which is brought into use if the oil level falls, by a float control. Leakage water seeping to the bottom of the turbine top cover is pumped out by two motor-driven pumps, one of which is a standby and is brought into use through "No-flote" gear, if the main pump fails to cope with leakage water; this system of drainage prevents flooding of the bearing. The lower end of the turbine shaft is sealed by a "Huhn" box, which comprises a number of carbon rings held against a sleeve on the turbine shaft by garter springs, giving an efficient seal.

The turbine is controlled from an actuator which operates the main servo-motor for the guide vanes and the runner blade servo-motor in the hub, through relay valves. Pressure oil for the control system is provided by a pumping set with a motor-driven pump.

The turbo-alternator set is equipped with the normal protective devices to give warning of faults and in some cases (i.e. in the event of overspeed) cause the set to shut down automatically by tripping the control solenoid on the main turbine regulating valve. This solenoid-operated valve then overrides the governor by setting the main valve in the "to close" position, when the set will shut down.

Alternators

Each of the six alternators being supplied by the British Thomson-Houston Company, Ltd., Rugby, for Owen Falls power station has a maximum continuous rating of 16·7MVA at 0·8 power factor, 150 r.p.m., and the three-phase, 50 c/s output is generated at 11kV. The alternators were designed to allow for the future development of the transmission system: provision was therefore made for a short-circuit ratio of 1·6 (giving a line charging capacity of 16·7MVA at zero loading power factor with a substantial margin in excitation voltage) and for a voltage range at the alternator terminals of 11kV±10 per cent.

In addition, the high ambient temperature likely to be met, necessitated the temperature rises on full load being kept well below those normally permissible. A large flywheel effect of over 14,000,000 lb per square foot, giving an inertia constant (*H*) of 4·5, is incorporated in the alternator rotor, giving satisfactory speed governing and stability under line fault conditions. Stability is also assisted by the low transient reactance of 21 per cent and the use of a quick-response excitation system described more fully below.

The alternator stator is mounted above floor level and completely surrounded by a sheet steel casing (Fig. 13), square in shape and approximately 28ft across. The top of the casing is level with the gallery running the whole length of the station, on which are mounted the gauge panel, turbo-alternator starter board, field cubicle, and voltage regulator cubicle.

The alternators themselves are of the "umbrella" form with a combined Michell thrust and guide bearing mounted below the rotor and no guide bearing above it. The stator frame is of fabricated construction and was split into four sections (Fig. 15) for

transportation to site. Air discharge openings are provided round the periphery; dovetail key bars are fitted inside for holding the stator laminations in place. To achieve a high efficiency the stator core was built of low-loss, high-ductility steel laminations, which were specially supplied by the steel makers for these alternators. These laminations were insulated on both sides by the flash-enamel process to reduce eddy currents. They are clamped between segmental steel flanges, steel fingers being welded to the flanges for supporting the core teeth.

The stator winding is of the double-layer lap type and is short-pitched to reduce mainly the lower harmonics, the higher harmonics being reduced by radial shaping of the air gap and the choice of the appropriate number of stator slots. The winding consists of two circuits in parallel per phase and all six ends are brought out by flexible leads. To reduce eddy currents to a minimum one turn in each coil is transposed in the end winding. The individual turns are of rectangular copper wire, which is covered with asbestos, while those forming a complete turn are taped with bitumen-bonded mica, the end portions of the coil being reinforced mechanically with glass tape. The coils were vacuum dried and impregnated with bitumen and the straight portions then insulated with micafolium, ironed on hot, by the Haefely process. Corona shields consisting of asbestos tape treated with semi-conducting graphite paint are fitted, the asbestos tape giving mechanical protection in the slot. The top and bottom coils in the slot are spaced apart by separators which are shaped, where necessary, to accommodate thermocouples. The end portions of the coils are taped to non-magnetic support rings, spacer blocks being fitted between end turns. The whole winding is securely lashed with glass cord to prevent any movement when the machine is subject to a sudden short circuit. Winding protection caps and air shields are fitted and low-temperature heaters provided to prevent condensation when the machine is shut down.

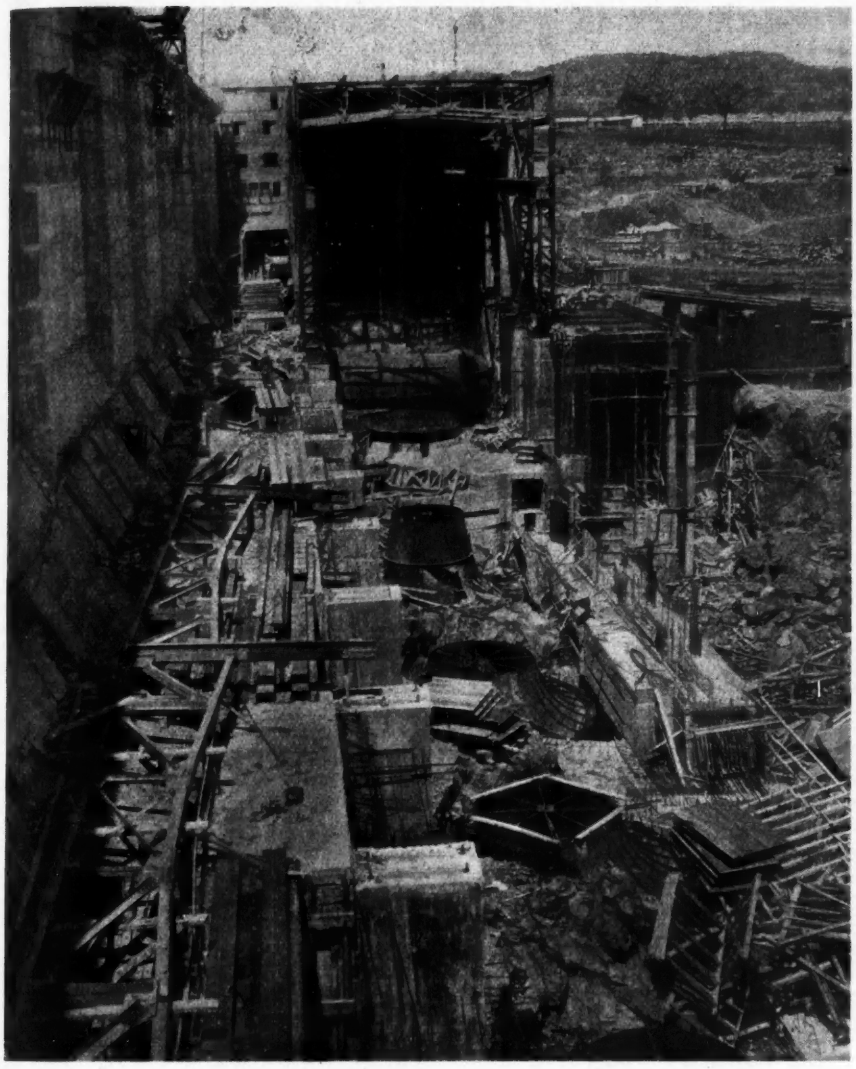


Fig. 11—Construction of Power-house, March 18, 1954

The rotor consists of a shaft, fabricated spider, rotor rim, and poles. The spider, which was shipped in two sections, is bolted to flanges on the shaft. The rotor rim, which is keyed to the spider, is built up of segmental steel plates, interleaved and bolted together in two sections. Because of transport difficulties, the individual plates had to be shipped loose and the whole rim built up at site. The pole laminations are clamped between forged steel end plates and the completed poles fitted in the T-headed slots in the periphery of the rim and secured by tapered keys. The complete rotor weighs about 130 tons and is approximately 19¼ft in diameter. It has been subjected to overspeed tests.

The natural fan action of the rotor is assisted by fans mounted above and below the rim of the rotor and air duct, between the two packets of the rotor comprising the rim, ensures that cooling air is transmitted to the centre of the stator core. A duct through the centre of each pole ensures that they also receive their share of the cooling air. Below the spider rim is a circle of segmental brake plates and against these press the combined brakes and jacks which are mounted on the arms of the bearing bracket. The pistons of these brakes and jacks can be locked in any position by rotating a loose ring round the cylinder. When used as brakes they are operated by air from an electrically driven air compressor, two of which are supplied as station auxiliaries by the Westinghouse Brake and Signal Company, Ltd., King's Cross, London, N.1, but high-pressure oil from a portable electrically driven pump is used when they are employed as jacks.

With the exception of the first two alternators, on which the rotor coils, because of the production requirements, were machine wound, the remaining coils are of fabricated construction. To assist in cooling, a number of turns of the machine-wound coils project at the ends of each coil, a similar effect being achieved on the fabricated coils by inserting sections of greater width. The major insulation is of "Micanite," which is mechanically reinforced with varnished pressboard and the winding is supported by flanges of moulded insulation. A short-circuited winding of copper rods in semi-closed slots is provided in the laminations near the pole face to damp any oscillations which may be generated by disturbances on the system, to prevent hunting and to reduce harmonic voltages under unbalanced load conditions.

The bottom bracket which houses the combined thrust and guide bearing consists of a hub with eight radial arms bolted on. The maximum load carried by the thrust bearing, including hydraulic thrust, is 465 tons. The thrust and guide bearing parts are submerged in a bath of oil, this oil being circulated through an external cooling system. Sight flow indicators, a level switch, and bearing thermometers are provided with contacts to give an alarm in the event of failure of the lubricating system. The oil is circulated by a 7½ h.p. a.c. motor-driven pump and a similar pump, driven by a 240V d.c. motor, acts as a standby. This pump automatically starts should the oil pressure fall below a predetermined value and cuts out when normal pressure is restored. These pumps are supplied by Mirrlees (Engineers), Ltd., Hillington, Glasgow.

The top bracket consists of a hub and eight radial arms which span the top of the stator. This bracket carries the magnet frame of the main exciter and supports the top portion of the outer casing. Apart from the "Combinator," the main exciter only is mounted above the alternator rotor, hence the overall height of the set is kept to a minimum. This is achieved by the use of a special excitation system described later.

The alternators are ventilated on the closed-circuit system, the continuously circulated air being cooled by eight air/water heat exchangers arranged in pairs at the four corners of the square formed by the outer casing. Hot air is discharged through openings in the stator frame and passes through the coolers into the four corners. Part of the air thus cooled passes into the underside of the machine through ducts, the remainder into the top of the machine through openings between the arms of the top bracket. The main exciter is included in the alternator

ventilation system. An electrically driven fan, mounted between two arms of the top bracket, forces cooled air from the alternator system through a duct into the exciter. The air is then discharged back into the alternator through a number of filters spaced round the underside of the exciter frame. A differential pressure gauge is fitted across each air cooler to give warning should there be either a failure of the cooling water supply or a blockage in the cooler. Inlet and outlet air thermometers with alarm contacts are spaced round the alternator block.

Carbon dioxide fire suppression equipment, supplied by The Pyrene Company, Ltd., Brentford, Middlesex, is provided for each alternator and arranged for initial and extended discharge of CO_2 into the air circuit. A bank of cylinders supplies all machines, the CO_2 being routed to a particular machine by electrically operated valves. Operation of the equipment is initiated by the alternator circulating current protection relay or manually by the "Emergency Stop with CO_2" push button on the gauge panel. Similar equipment is provided for the protection of the bearing oil tanks.

The excitation of the alternator and the supply for the governor pendulum motor are provided by a special system. Instead of the conventional main and pilot exciters and governor generator mounted on the alternator shaft there is a single constant-voltage direct-coupled d.c. machine in association with a separately driven auxiliary exciter set; these machines are controlled by a hard valve electronic voltage regulator. A simplified schematic diagram of the scheme is given in Fig. 14. The constant-voltage main exciter, which is mounted above the alternator rotor, is a self-excited, compound-wound d.c. generator, having a specially designed magnetic circuit so that the variation in exciter flux with variation in speed is small. Three sliprings connected to tappings on the armature provide a three-phase, 15-c/s supply for the governor pendulum motor and the voltage regulator power supply. A motor-operated rheostat is connected in series with the main exciter shunt field to take care of initial adjustments and abnormal operating conditions.

The auxiliary exciter set, which runs at 1000 r.p.m., comprises an auxiliary exciter and amplidyne generator driven by a d.c. motor which receives its supply from the main exciter. The auxiliary exciter is connected in series with the main exciter armature and is arranged to buck or boost the output voltage of the main exciter, thus providing a variable voltage supply to the alternator field. The excitation of the auxiliary exciter is provided by the amplidyne, which in turn is controlled by the electronic voltage regulator. Two field switches are housed in the field control cubicle and, when opened, suppress the alternator field and the main exciter field. To ensure that the main exciter voltage builds up at a suitable rate when starting the turbine, an auxiliary field on the main exciter is connected through a contactor to the 240V station battery, this contactor being closed before starting up and opened by a current relay as soon as the exciter shunt field current has reached a preset value.

The possibility of the turbine being accelerated more quickly than the main exciter could build up its voltage had to be considered, as this contingency would result in the pendulum motor not reaching synchronous speed by the time the set had reached synchronous speed, causing the set to continue accelerating. An alarm circuit, utilising a voltage relay and speed relay is included to detect this condition, but from tests already carried out this possibility appears to be remote.

The voltage regulator, which is housed in a separate cubicle, employs a saturated diode, forming part of a voltage-sensitive bridge circuit supplied from the alternator terminals through a potential transformer. Any deviation in the bridge output is amplified and immediately produces a corresponding change in the amplifier output, which, in turn, influences the alternator excitation through the medium of the amplidyne and auxiliary exciter in the correct sense to restore normal voltage. Positive-phase-sequence networks ensure correct voltage regulation under unbalanced loading conditions and compensation circuits provide satisfactory reactive load sharing between alternators running in parallel. Electronic control circuits are duplicated and fault discriminating relays are provided to give automatic transfer from a control unit which has developed an internal fault to a standby unit. In the event of an external fault, such as failure of the potential transformer supplying

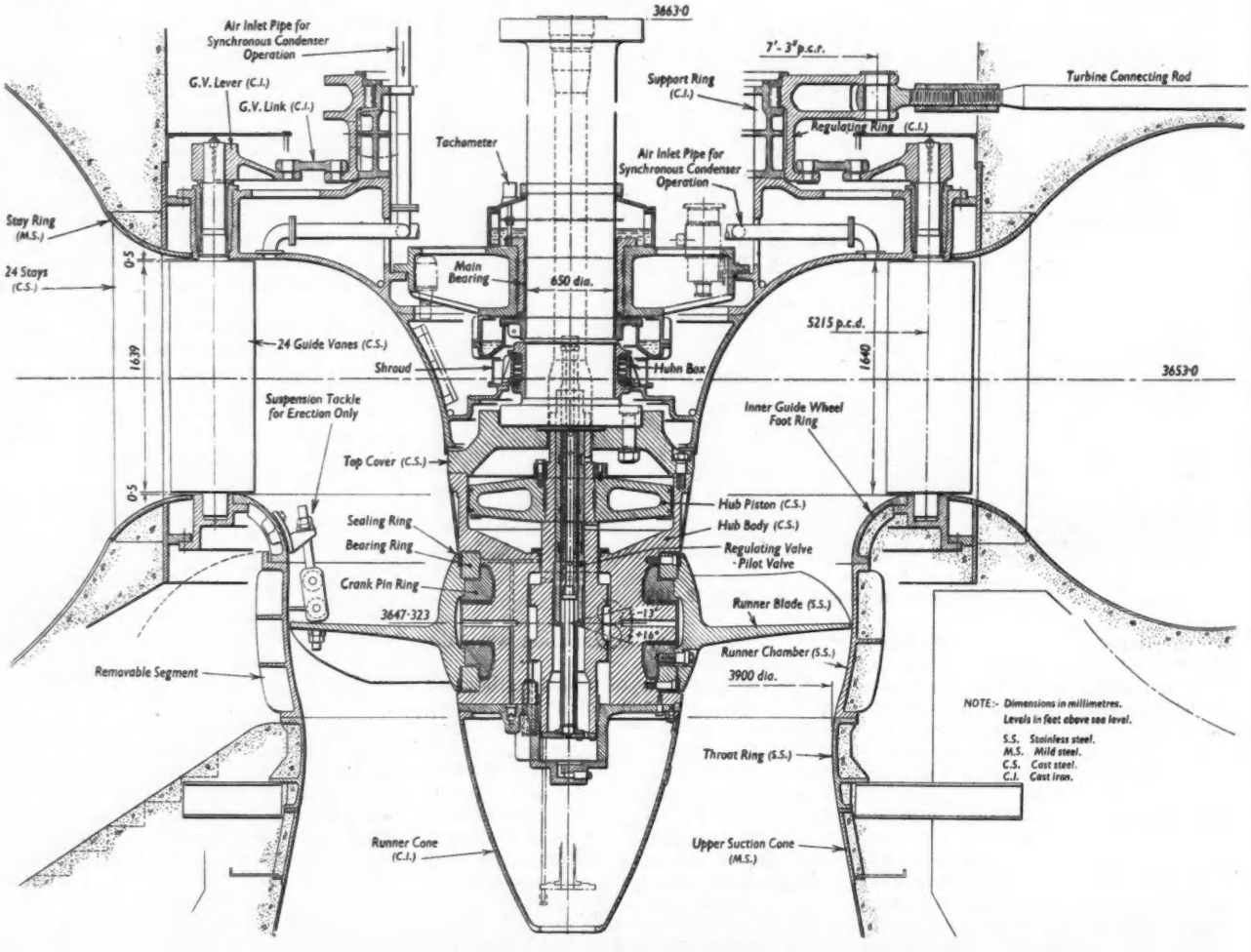


Fig. 12—Section Through Turbine in Owen Falls Power Station

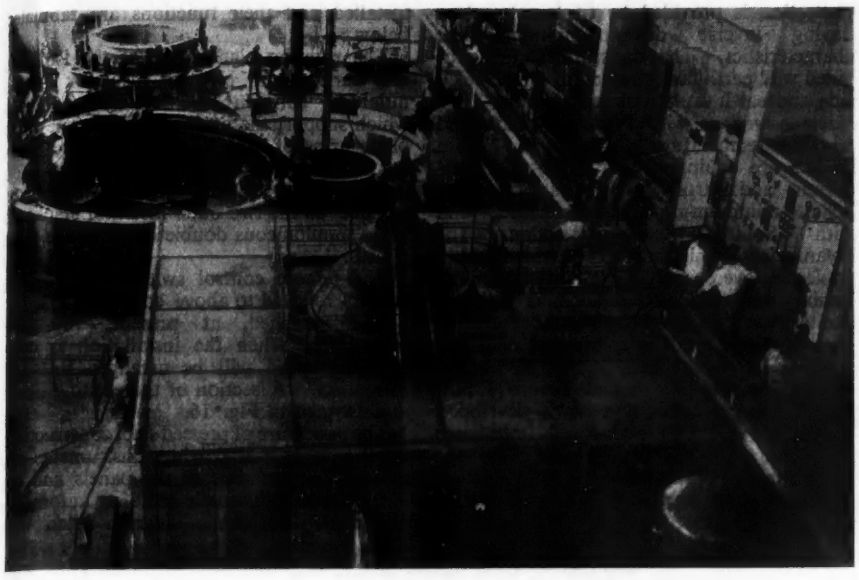


Fig. 13—No. Alternator and Stator of No. 2 Alternator During Erection

the regulator, the regulator is switched directly to hand control. To prevent hunting and to ensure optimum rate of recovery following load changes on the alternator, transient negative feed-back voltages derived from the auxiliary exciter armature, amplidyne armature and amplidyne winding are fed into the amplifier.

The speed of response of the system is high, since control is effected through a high-speed auxiliary exciter instead of a relatively large low-speed main exciter. In the presence of line faults full ceiling volts are available, as the supply to the auxiliary exciter set driving motor is unaffected by the line conditions.

The control equipment is arranged essentially for hand control of the machine, although certain automatic facilities are incorporated. The gauge panel and unit starter board are mounted together, forming a complete control board. A portion of the first panel can be seen during installation in Fig. 13. Fluorescent lighting fittings are mounted along the top of the board for panel illumination. The gauge panel is divided into five sections labelled "Transformer," "Alternator," "Alarms and Communication," "Turbine" and "Hydraulic," and the applicable controls and indications are mounted on individual sections. A cubicle forming a passageway is positioned between the gauge panel and starter board and allows rear access to the various cubicles. The starter board houses the incoming 415V a.c. power supplies from both the station 500kVA, 33kV/415V auxiliary transformer and the 50kVA, 11kV/415V unit transformer, together with the 240V d.c. supply and the starters for the various unit auxiliaries.

On starting up from the unit supply the alternator bearing and turbine bearing d.c.-driven standby pumps are run up from the starter board and the contactors controlling the other a.c. auxiliaries are closed. The turbine can be started by pressing the "Start" button on the gauge panel (which disengages the guide vane lock) and then running the load limiter towards the "Open" position by the control switch on the gauge panel. As the machine runs up to speed and the voltage of the unit transformer increases, the motors driving the governor and main bearing oil pumps also run up and the bearing pumps automatically take over the loads of the standby pumps. The turbine standby pump is shut down by pressing the "Stop" button on its starter compartment, but remains available for re-starting automatically should the level of oil in the bearing subsequently fall. On shutting down, the voltage of the supply from the unit transformer drops and the oil pressures from the main bearing oil pumps fall. The standby pumps cut into circuit, thus ensuring adequate lubrication while the set is coming to rest. The brakes are arranged for automatic operation in the event of faults necessitating the rapid shutdown of the machine, once the speed has fallen below 150 r.p.m.; alternatively, they can be applied by hand once the speed has fallen below 80 per cent of normal.

Alarm signals from the alternator transformer, alternator and turbine are indicated on six-way alarm fascias provided on the gauge panel and certain individual and group signals are relayed to the control room. A telecommand receiver and sender switch, together with a telephone, are also provided to allow rapid communication between the turbine driver and the control room. This alarm and communication equipment was supplied by Standard Telephones and Cables, Ltd., New Southgate, London, N.11.

The principal station controls are grouped in a main control desk, which gives facilities for (1) the display of all switchgear and generator alarms; (2) the transmission of stereotype orders from the control room to the turbine gauge boards and vice versa; (3) telephonic communication with the turbine gauge board; and (4) a display of alarms associated with battery chargers, system fuses, &c.

The desk consists of a central writing position which contains a "PABX" operator's cabinet and which is flanked by two wing sections on which are mounted the control keys and alarm displays for the facilities mentioned above. The left-hand wing is associated with the turbo-generators, besides the alarm displays; it carries the telecommand keys and displays for the transmission of the stereotype orders. The right-hand wing displays the switchgear alarms and supply-fail alarms. A special system of alarm display, which is designed to economise in space, is used; the alarms are displayed in groups such that generator and feeder has its own separate group.

The equipment for the transmission of stereotype orders to the turbine gauge boards is of new design and consists of a rotary switch by means of which any one of up to eight orders may be selected. The order is sent by depressing the switch knob of the switch in the selected position. This causes a lamp to flash at either end and the flashing is steadied when the receiving end accepts the order. The whole equipment, like the other equipment installed on the desk, operates at 50V d.c. and uses telephone technique and wiring.

Overall protection of the alternators is provided by G.E.C., Merz-Price equipment, which is responsive to all phase and earth faults in the machine. All the relays in this system are energised from current transformers in the generator neutrals and generator cubicles. They have a ratio of 1000/1 and an operating time of 15 milliseconds. Overload protection is given by a three-pole overcurrent relay with inverse, definite minimum characteristic, energised from current transformers in the alternator neutrals. Earth fault protection is given by an instantaneous, attracted-

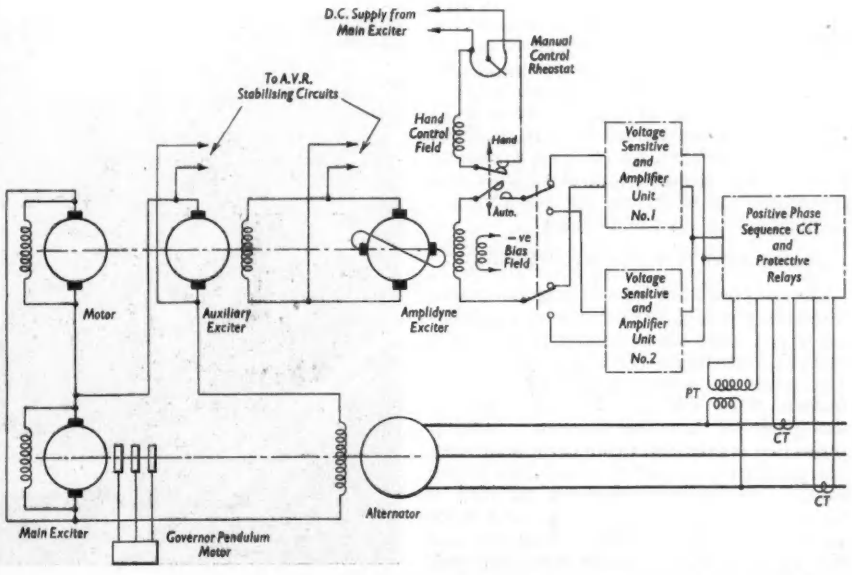


Fig. 14—Schematic Diagram of Excitation System

armature relay with a sensitivity of 7A, primary current. This relay is energised from a 100/1 current transformer connected in the earthing resistor circuit. By using 63·5 ohm earthing resistors the earth fault current on the 11kV side is limited to 100A. On each panel the trip relays are equipped with reset coils so that resetting can be effected electrically from the control room.

Transformers

Each of the first four alternators will be solidly connected to an outdoor 16·67MVA, 11/33kV generator transformer and through 33kV oil break switchgear to duplicate 33kV busbars connected to 33kV feeders to Njeru, Nyanza and Tororo. Through 33kV switchgear and two 7·5MVA, 33/66kV transformers these busbars also supply two feeders to Lugogo.

The 33kV busbars will be connected through 20MVA, 33/132kV inter-bus transformers to duplicate 132kV busbars. The 132kV busbars will also be supplied from No. 5 and No. 6 alternators (which will complete the generator installation) through two 16·67MVA, 11/132kV transformers with overhead line feeders to Kampala and Tororo.

The main transformers are delta/star water-cooled core transformers, wound with disc coils and interlocked spacers which are free to slide when the coils are being tightened, without being able to work loose in service.

Duplicate forced-oil coolers provide 100 per cent standby facilities, one complete cooler with its totally submerged motor-driven oil pump being located at each end of the transformer. Each pump can deal with the full-load cooling requirements by forcing oil through the Serck cooler, which consists of a nest of small-bore tubes mounted in a jacket through which cooling water is circulated. Each cooling equipment includes an electrically operated water valve, an oil pressure valve on the outlet side of the cooler to ensure that the pressure of the oil is always above that of the water, an oil flow indicator, and a differential pressure gauge with alarm contacts to give warning in the event of the water pressure exceeding that of the oil.

An overhead line to Lugogo is fed by 7500kVA, 33/66kV delta/star-connected outdoor oil-immersed naturally cooled transformers fitted with detachable radiators, each of which has a hand-operated inlet and outlet valve, an oil conservator with magnetic type oil gauge, an explosion vent, a reactor type motor-operated on-load tap changer on the 33kV side to give a voltage variation of plus and minus 10 per cent in sixteen steps of 1¼ per cent each, all tappings being fully rated. A marshalling box fitted to the front of the transformer tank contains a winding temperature indicator, control switches and contactors for operating the tap changer, terminal board, fuses and heater.

Transformer and Feeder Protection

Overall protection for the generator transformers is provided by G.E.C. biased differential relays, which are responsive to phase and earth faults on either side of the transformer. The relays are energised by current transformers in the 33kV circuit breakers and in the generator terminal cubicles. Back-up protection is provided by an earth fault relay energised from a current transformer in the neutral. Overvoltage relays are provided to trip the set in the event of overspeeding under fault conditions, and the transformers are also equipped with Buchholz relays and with winding and oil temperature alarm devices.

On the 66kV Lugogo feeders overcurrent protection is provided by triple-pole relays having inverse definite-minimum-time characteristics. The transformers are provided with earth fault protection on the 66kV side and earth fault protection on the 33kV side, as well as with Buchholz relays and winding temperature alarms. The Njeru feeders are equipped with triple-pole overcurrent and earth fault relays of inverse definite-minimum-time characteristic, and with "Solkor" feeder protection. The Nyanza textile mill feeder is provided with a triple-pole overcurrent relay of inverse definite minimum-time characteristic, and with instantaneous earth leakage protection. A two-way surge proof inter-tripping scheme is provided for this feeder.

The Kampala North and Tororo 132kV feeders are protected by a newly developed scheme of Reyrolle high-speed impedance protection having three stages. They are also equipped with carrier communication equipment and the Kampala North circuit, includes high-speed carrier inter-tripping facilities. Arrangements are also made for single-shot slow-speed auto-reclosing on both of these feeder circuits.

Switchgear

The 33kV outdoor substation at Owen Falls consists of fourteen bays containing twelve frame-mounted 33kV oil circuit breakers and forty-five rotary isolators.

The circuit breakers have a breaking capacity of 750MVA at 33kV, and a full-load current rating of 800A. Each breaker consists of three separate double-break, low-oil-content single-phase units mounted in steel tanks, supported by a steel framework, a form of construction which allows the contacts to be inspected without removing the oil from the tank or breaking oil-tight joints, and a single phase of the breaker to be removed bodily and replaced by a spare unit at any time.

Of the forty-five rotary isolators in the substation, forty-three are for 33kV and two for 66kV. Particulars of the various types installed and their functions are tabulated below :—

The rotating blade arms of the isolators are carried on pivoted insulator stacks mounted between two stationary stacks which support the fixed contacts. The three blade arms of a three-phase unit are interconnected by the operating rods and, on being rotated, each disengages with the fixed contacts on the two outer insulator stacks, to give a simultaneous double break in the three phases.

The remote control switchboard for the circuits referred to above consists of G.E.C. panels arranged, at present, in "L" formation. When the installation is complete the board will be arranged in "U" formation. A section of the existing board is illustrated in Fig. 16.

The panels are of pressed steel construction, 7ft 9in in overall height. Instruments are mounted at the tops of the panels and the centre portions accommodate an automatically controlled mimic diagram fitted with discrepancy type control switches, each of which combines the functions of a circuit breaker control switch and semaphore indicator. The operating handle is a raised bar, which completes the line diagram when the corresponding circuit breaker is closed, and breaks it when it is open. A lamp, enclosed by a "Perspex" dome behind the bar, is illuminated automatically if the condition of the circuit breaker and the setting of the operating handle do not coincide.

The remaining control switches and lamps are mounted below the mimic diagram. The control desk is level with the end units of the control board so as to be at the head of the eventual "U" formation. The relay panels are mounted in a separate room.

The 132kV switchgear for Owen Falls power station is of Reyrolle "OS10" pneumatically-operated outdoor small-oil-volume design having a proved breaking capacity of 2500MVA. The initial installation consisting of five circuit breakers, together with their associated three-post

Particulars of Rotary Isolators at Owen Falls

Quantity	Voltage, kV	Current, A	Type	Function
26	33	400	Double-break horizontal rotary, low level	Busbar isolators
10	33	400	Double-break rotary	Voltage transformer isolators
4	33	400	Double-break rotary with earthing switches	Feeder isolators
1	33	400	Dual rotary	Transformer isolator
2	33	800	Double-break rotary	Bus couplers
2	66	400	Vertical-break rotary with earthing switches	Feeder isolators

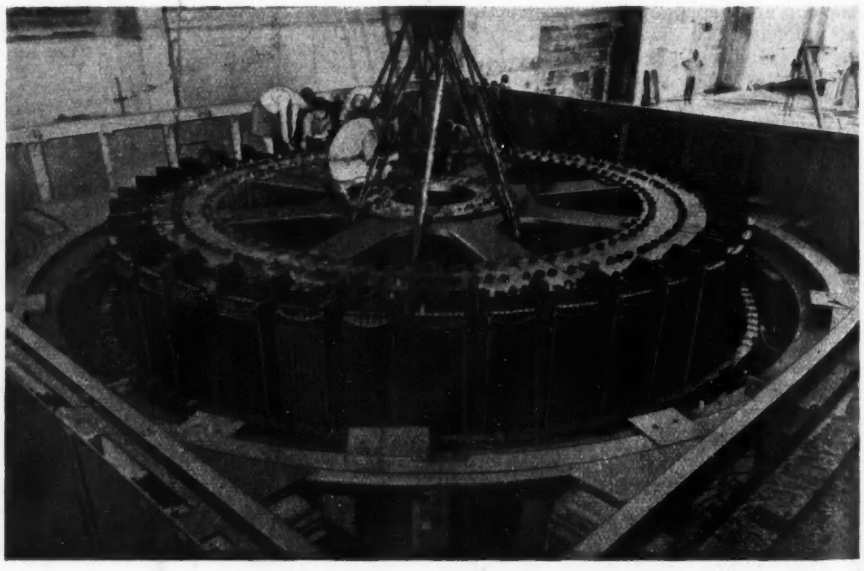


Fig. 15—Alternator Rotor Being Lowered Into Stator

rotary type isolators, post type current transformers and capacitor type voltage transformers are connected to a single set of tubular copper busbars. Generators 5 and 6, which are solidly connected together through isolators, are controlled by one circuit breaker and the others control two interbus transformers and feeders to Kampala North and Tororo.

The civil engineering works of the Owen Falls scheme are now largely completed, except at the power station, where additional turbo-alternator sets will be installed as need for them arises. Work was started in 1950 and the first machine was brought into operation at the beginning of this year. The second set was due to be in operation by the time of the opening ceremony ; two more sets are being installed and two more have been ordered, of the ultimate installation of ten 15MW sets. The direct cost of the scheme is estimated at £11,000,000, including

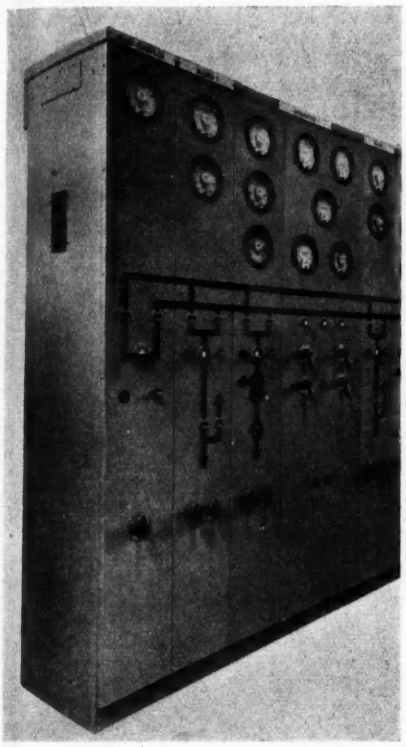


Fig. 16—Part of Remote Control Switchboard

installation of six of the ten sets, with an additional £2,000,000 of indirect charges.

The Uganda Electricity Board has been the promoter of the scheme, and its consulting engineers are Sir Alexander Gibb and Partners for the civil engineering, and Messrs. Kennedy and Donkin for the electrical and mechanical engineering of the scheme. The Board's chemical consultant, Dr. A. J. V. Underwood, advised on problems in chemical and cement projects related to the scheme.

The civil engineering and building work of the scheme was contracted to the Owen Falls Construction Company, a group of four British and four Dutch firms, namely : Christiani and Nielsen, Ltd., Dorman, Long and Co., Ltd., Edmund Nuttall Sons and Co. (London), Ltd., J. L. Kier and Co. (London), Ltd., Hollandsche Beton Maatschappij N.V., Internationale Gewapend Beton Bouw N.V., Nederlandsche Aanneming Maatschappij N.V., and Nederlandsche Beton Maatschappij Bato N.V. The aggregate plant was supplied by Pegson, Ltd., and the concrete batching plant by Winget, Ltd.

The electrical and mechanical contractors are listed herewith :—Structural steel, Redpath Brown and Co., Ltd.; water turbines, Boving and Co., Ltd.; generators and 33/132kV transformers, British Thomson-Houston Company, Ltd.; protective equipment and 33kV switchgear, General Electric Company, Ltd.; 132kV switchgear, A. Reyrolle and Co., Ltd.; generator transformers and 33/66kV transformers, Bruce Peebles and Co., Ltd.; control desk, Standard Telephones and Cables, Ltd.; overhead lines and cables, B.I.C.C., group of companies; water control gates, Glenfield and Kennedy, Ltd.; 120-ton power station crane, Sir William Arrol and Co., Ltd. Turbine sub-contractors : the first four turbines have been built by John Brown and Co., Ltd., the runners being made by Markham and Co., Ltd., which firm is to manufacture the fifth and sixth turbines. The various auxiliary motors were by B.T.H., Ltd., the auxiliary pumps by the Hamworthy Engineering Company, Ltd., and the oil pressure control system pump by Mirrlees (Engineers), Ltd.

The British Industries Fair

No. II—*(Concluded from page 634, April 30th)*

THE British Industries Fair opened at Castle Bromwich in Birmingham and at Earls Court and Olympia in London on Monday, May 3rd, and will be open until Friday, May 14th. Some of the exhibits of engineering interest are described here.

Rapid Magnetic Machines, Ltd.

The many forms of permanent and electromagnetic equipment for use in diverse industries which will be exhibited by Rapid Magnetic Machines, Ltd., Lombard Street, Birmingham, 12, includes the new " Magnahump," shown in Fig. 14.

This piece of equipment is designed to provide a double protection for processing plant against damage from tramp iron. It can be used for extracting such iron from wet or dry materials conveyed through cylindrical or rectangular ducts, closed chutes and pneumatic pipelines, or where space limitation or material consistency excludes the conventional 45 deg. angle gravity feed.

It is fitted with two " Alcomax " magnet units, so disposed that the material impinges upon the first magnet, changes direction and flows over the second unit. This procedure ensures that the iron content, whatever its position in the feed, is brought in direct contact with the magnet pole faces where the magnetic strength is the greatest. The extracted iron is held until the magnet unit is manually cleaned. To facilitate this work the magnets are hinged and swing open on the release of the latch.

The " Magnahump " is manufactured in two types, one for gravitational or pneumatic applications and suitable for extracting tramp iron from dry materials such as cotton or grain. The other design, known as the " Hydrohump," can work with internal pressures of up to 30 lb per square inch, and is applicable for use in handling pulp paper stock, chemicals, slurries, &c., under pressure.

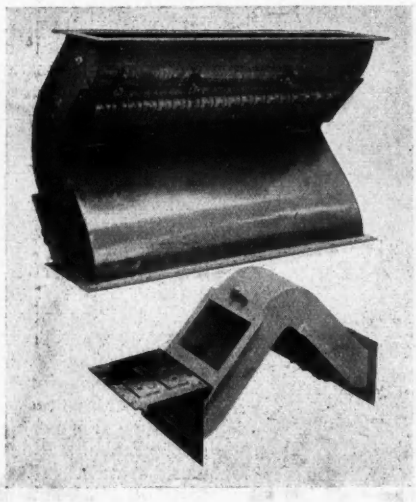


Fig. 14—" Magnahump " for Removal of Tramp Iron—Rapid Magnetic

Also illustrated here (Fig. 15) is the firm's " Magnatrap," which can be used in pipelines to remove tramp iron and fine iron suspended in such things as foods, juices,

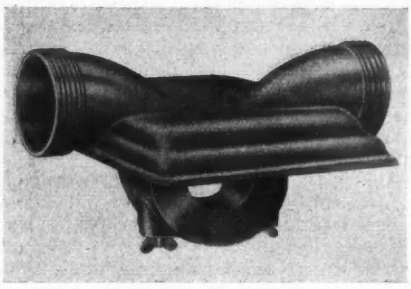


Fig. 15—" Magnatrap " for Pipelines—Rapid Magnetic

and paints. It is made in stainless steel for the food industries and aluminium alloy for other applications, and is designed for easy installation in existing standard pipelines. The design of the trap eliminates induced turbulence whilst ensuring that the stream of fluid passing through is subjected to a powerful impinging field over the whole magnetic area. Its self-energising magnetic unit is held in position by two wing nuts and can quickly be removed for cleaning.

Westinghouse Brake and Signal Company, Ltd.

Amongst its well-known range of equipment the Westinghouse Brake and Signal Company, Ltd., 82, York Way, London, N.1, will exhibit the " Westruk 960 " truck illustrated in Fig. 16. This equipment is a transportable plant designed for aircraft hangar maintenance, apron servicing and engine starting. It provides 500A, d.c. continuously for maintenance and servicing work and a peak of up to 2000A for aircraft starting purposes. All aircraft using the 28·5V system can be serviced and started with the equipment.

The equipment of the " Westruk " includes a double wound, three-phase transformer ; a double-voltage, full-wave bridge connected rectifier ; a mains contactor and an overcurrent protective system.

A dual range ammeter and voltmeter are fitted under a " Perspex " panel and suitably illuminated. The lower range of the ammeter enables the servicing load to be observed accurately and the higher range will indicate the peak loads.

These components are mounted in an

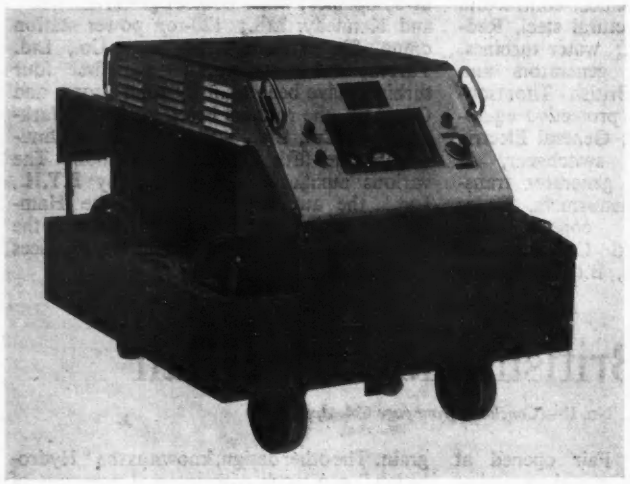


Fig. 16—Truck for Aircraft Starting and Ground Power Supply—Westinghouse

iron framework carried on cushioned rubber wheels and enclosed by sheet steel panels. The whole equipment is weatherproof for use out-of-doors. In two panniers, one fitted to either side of the body, two separate direct current cables are stored whilst the starter is being moved. Improved alternating current and direct current cable entries and glands are fitted. The alternating current consumption is 25A approximately when the direct current load is 500A, and an average of 65A under peak starting conditions.

Among the exhibits is a new form of barrier for highway crossing protection designed for use as an alternative to the heavier design of level-crossing gate. This barrier is designed for mounting on a 5½in diameter pipe post on which the operating mechanism is rigidly attached. The barrier arm mechanism is driven through gearing by a direct current series motor from a 12V or 24V supply. This motor drives the barrier arm from the horizontal to the vertical position where it is securely held by an electrically operated brake. The arm is counterbalanced but biased to return to the horizontal position when the brake is released. During its descent the speed of the arm is governed by means of rheostatic braking, and it can be reversed through the control gear at any point during the lowering operation.

Auto Diesels, Ltd.

Auto Diesels, Ltd., of Uxbridge, is exhibiting a selection from its standard range of generating and lighting equipment. The generating sets include a dual-voltage, dual-frequency machine to operate at both 400V, three-phase, 50 c/s, and 230V, three-phase, 60 c/s.

The new equipment shown includes a 500W close-coupled, petrol-engine-driven generating set available in all standard voltages. It has a single-cylinder, four-stroke, light-weight, air-cooled petrol engine rated 1·25 b.h.p. at 3000 r.p.m. The alternator equipment is 0·625kVA at 0·8 p.f. 230V, single-phase, 50 c/s. This alternator is a screen-protected, self-exciting, self-regulating, single-bearing machine.

The built-in switchgear is completely enclosed and includes voltmeter, field regulator, fuse and output terminals. The set is built up of light materials and weighs about 88 lb. It is fitted with carrying handles.

G.W.B. Furnaces, Ltd.

The exhibits of G.W.B. Furnaces, Ltd., Dibdale Works, Dudley, Worcs, include the firm's "Autolec" electrode steam raisers and water heaters and the "Powermaster" oil or gas-fired boiler illustrated in Fig. 17. This self-contained "packaged" boiler is made in a range of sizes from the smallest giving from 517 lb of steam, or 502,125 B.Th.U. per hour for hot water, to the largest with an output of 17,250 lb of steam, or 16,737,500 B.Th.U. per hour for hot water. It is fitted with a full range of automatic controls and a motor-driven forced draught fan.

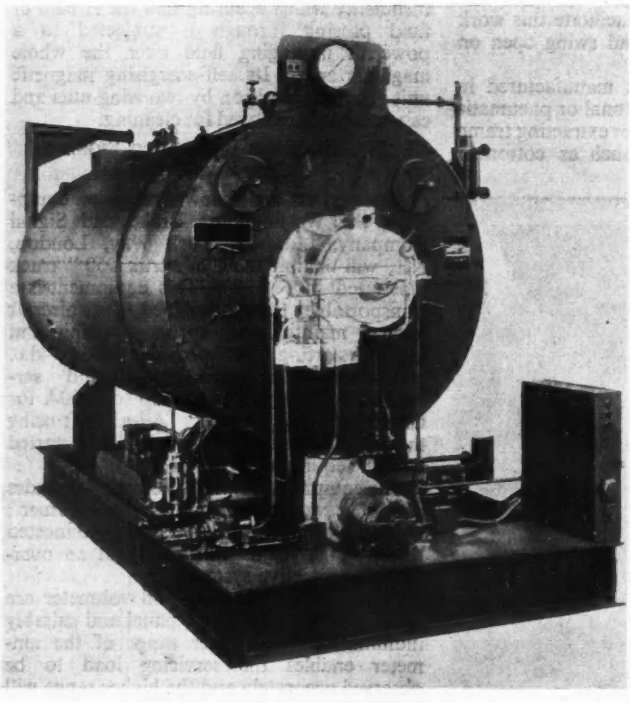


Fig. 17—"Powermaster" Boiler—G.W.B.

The boiler is assembled on a sectional steel base complete with burners, forced draught plant, control gear, &c. A combination burner fitted is designed to work on oil or gas, or both, and changing over from one form of fuel to the other involves no shutting down for mechanical alterations or adjustments. The flame of the burner is projected down a central chamber running practically the full length of the boiler, and the hot gases pass through two sets of return tubes before exhausting to the flue outlet.

Flame safety control gear is arranged to shut off the fuel supply automatically should the flame be extinguished during operation. Automatic control gear is also fitted to adjust the rate of combustion for constant operating pressure or temperature, and for controlling the water level during operation.

Access to the interior of the boiler and the tubes is through a rear door which is hung upon a davit and can quickly be removed. If required, a feed equipment, which includes condensate tank, float-operated valve and motor-driven feed pump, can be supplied with the boiler.

W. and T. Avery, Ltd.

In Fig. 18 there can be seen a new testing machine made by W. and T. Avery, Ltd., of Birmingham, for precision tensile testing up to 2500 lb on a wide range of materials from metallic wire to plastics, textiles and cement.

On this machine the load is indicated on a clearly graduated chart, whose numbers

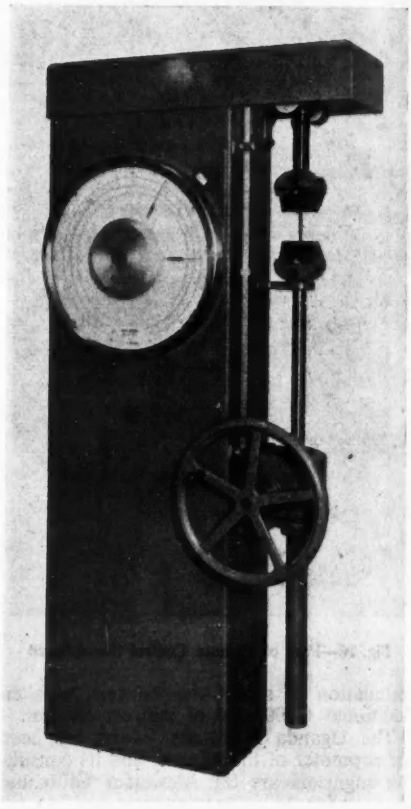


Fig. 18—2500 lb Testing Machine—Avery

change as each of the three load ranges on the machine is brought into operation. These ranges cover one-fifth, one-half and full capacity. The indicator is fitted with a maximum pointer to show the maximum load reached during a test, and load pacing gear can be fitted.

In this machine strain is applied by hand-operated worm and screw gearing. It is designed to accommodate a wide range of interchangeable gripholders.

Wedge grips can be supplied for testing wire, sheet or strip and heavy non-metallic materials, such as leather or canvas; drum grips for testing cords, lines, twines, and

special grips for rubber, cement and moulded plastics.

Taylor and Challen, Ltd.

Three presses are exhibited on the stand of Taylor and Challen, Ltd., of Birmingham. One of these machines is the smallest of the firm's range of coining presses and is designed to produce bronze coins up to $\frac{3}{4}$in diameter or silver coins up to $\frac{7}{8}$in diameter, at a rate of 150 coins a minute.

Another of the machines is the notching press illustrated in Fig. 19, which is particularly intended for notching sprocket

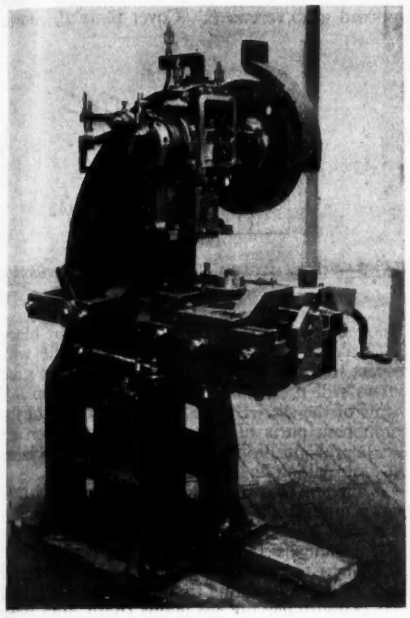


Fig. 19—Notching Press—Taylor and Challen

wheels from 2$\frac{1}{4}$in to 10in diameter. It is tooled up for notching bicycle chain sprockets having forty-six teeth. Its automatic feed rotates the wheel blank between dies, which first cut out the rough form of the sprocket teeth. The centre of the feed is then advanced slightly for a second cut, which completes the forming of the teeth. The feed then automatically returns to its original position for receiving the next blank. When cutting small freewheel sprockets the press is arranged to give three cuts : a roughing cut, a second cut and a finishing cut. The dividing wheel is easily changed, being situated under the saddle, and the other adjustments needed for notching different diameters of sprockets with different numbers of teeth are quickly and simply effected.

The press is driven by a 3 h.p. motor running at about 420 r.p.m. and the speed of notching is 300 strokes per minute.

Bronx Engineering Company, Ltd.

A press brake of 90 tons capacity designed for bending mild steel plates up to 8ft wide and $\frac{3}{16}$in thick is being shown by the Bronx Engineering Company, Ltd., of Lye, near Stourbridge. This machine (Fig. 21) has a width of 8ft 4in between the columns and its beams are 10ft long. It has a stroke of 3in and its ram has an adjustment of 5in.

The frame of the machine is of all-welded steel construction with the driving shaft and gearing mounted in a heavy crown framework. The main drive from an 8 h.p. slipring motor in the crown is transmitted through double-reduction gearing to twin eccentric shafts. A flywheel in the drive is fitted with a multi-plate friction clutch and runs on ball and roller bearings. The top beam is motorised and is controlled by means of a push button, limit switches being provided to prevent overrun when setting.

A four-roll, initial-pinch plate bending machine on this stand is designed to bend mild steel plate up to 10ft wide by $\frac{1}{4}$in thick in a complete circle in one pass with a minimum of flat on the long edges.

Its centre bottom roll is adjusted vertically by means of a handwheel for gripping the plate. The two side bending rolls are individually adjusted by means of separate 6 h.p. motors which are controlled by means of push button direct-on starters. The top roll is not adjustable, but the bottom pinch roll is adjustable for plate thickness and can be tilted for conical work. The two outside bending rolls can be tilted for conical work. A multi-jaw clutch is arranged on each driving shaft so that one end of the roll is operated for conical setting. The position of the side bending rolls is shown by pointers on to a graduated scale mounted alongside the roll chocks. The top roll has a long counterbalancing extension for retaining the roll when the end bearing swings down. A support at the extreme end of the machine, which engages the ball end of the roll, is operated by means of a handwheel.

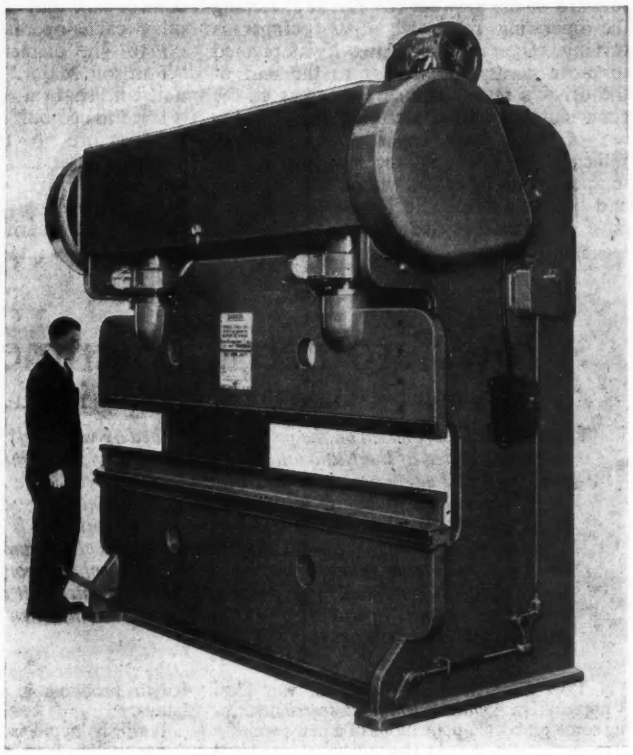


Fig. 21—90-Ton Press Brake—Bronx

Jack Olding and Co., Ltd.

Jack Olding and Co., Ltd., Hatfield, Herts, is exhibiting two new items of earth-moving equipment made by Onions and Sons (Levellers), Ltd., and distributed by the former company. The scraper illustrated (Fig. 20) is cable-operated, with a struck capacity of 2·7 cubic yards and a heaped capacity of 3·6 cubic yards. Like the cable control unit also shown in the illustration, it is intended for use on smaller earth-moving contracts, such as the construction of housing estate roads.

The scraper is of open bowl construction and is intended for tractors of 6000 lb minimum drawbar pull. It has a weight of 1 ton 18 cwt, a cutting blade 5ft 4in wide, and overall dimensions of 6ft 1in wide, 128$\frac{1}{2}$in long and 65$\frac{1}{2}$in high. The minimum non-stop turning circle of the scraper is 16ft in diameter.

In the cable control unit, which has been designed for use with the " Fordson Major " tractor, spur gear reduction is used to enable the rope drums to be set transversely with the swinging fairleads directly above. The makers point out that this design reduces overhang as far as possible and places the swinging point of the fairleads slightly

Fig. 20—Tractor with Cable Control Unit and 2·7 cubic yard Scraper—Olding

forward of the drawbar to prevent stretching the operating ropes when the scraper is turning. Operation is by two levers pivoted to move across the tractor to the rear of the driver's seat. The surface areas of the cone clutches and contracting band brakes are of extra large capacity, it is stated, sufficient to withstand the load of the $\frac{3}{4}$in scraper operating cables without overheating, and both are accessible for adjustment and have ventilated space for cooling. The control unit may be used for operating any other cable operated equipment employing up to $\frac{3}{4}$in diameter rope used with the "Fordson Major." The main body of the unit consists of a rigid steel fabrication with a large flange bolting securely to the rear of the tractor. A top carriage carries the swinging fairleads mounted on angular contact bearings, which are adjustable for wear. The rope pulleys are hardened and run on roller bearings.

Interferometric Alignment Set*

By P. W. HARRISON, B.Sc. (Eng.), A.M.I.Mech.E., A.C.G.I.

An alignment set based on the principle described by van Heel† has been designed, made and tested at the National Physical Laboratory; it is intended primarily for surveyors and engineers concerned with alignment over large distances. It comprises three units which are located at the three points to be aligned, and certain aspects of its design represent a departure from the methods used by Van Heel. The accuracy of this alignment set, like other optical instruments which operate over a considerable range, is influenced by atmospheric conditions. However, under optimum conditions, it is possible to set the centre unit on a line defined by the other two units to within ±0·0003in (±0·0076mm) when the latter units are separated by distances up to 120ft (37m).

IN 1949 an article† by A. C. S. van Heel appeared in *Applied Scientific Research* describing some practical applications of a new precision alignment method. As the technique promised to provide a greater accuracy at long ranges than other methods currently used, the National Physical Laboratory carried out its own investigation into the method with a view to the development of a set of alignment apparatus embodying the principle and suitable for use by engineers, surveyors and others engaged upon alignment over long distances.

Principle of Optical Method Employed

The idea of the van Heel method was first suggested by a classical experiment undertaken by Young (1773–1829) in which he allowed rays from the sun to pass through a small hole *A*

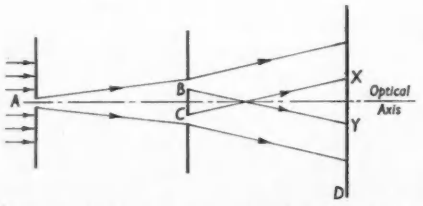


Fig. 1—Principle of Young's Experiment to Demonstrate Interference Bands

in a screen (Fig. 1) and then through two small holes *B* and *C* in a second screen, the light being received on a third screen at *D*. Young observed that interference bands were formed in the region *XY*.

According to the wave theory of light, holes *B* and *C* act as coherent light sources; provided that the holes are equi-distant and sufficiently removed from *A*, the approximately plane wavefront at *B* will be in phase with that at *C* as they both emanate from the same source. For white light the waves emerging from *B* and *C* either interfere or superimpose to form a fringe pattern as shown in Fig. 3. The typical fringe pattern is symmetrical about a central band of white light flanked on either side by two dark bands, which will be referred to as the "setting lines." These bands are orange-red on the inner edge, graduating through deep purple to blue on the outer edge. The rest of the pattern is composed of multi-coloured bands substantially equal in width, the brightness rapidly diminishing as the distance from the pattern centre increases. The substitution of light of a particular wavelength produces a series of dark and bright bands.

It will be appreciated from the above that the fringe pattern formed will be symmetrical about an axis passing through the middle of the single hole and the mid-point of the double hole, providing the plane of the holes is reasonably square to the axis. The pattern will therefore form a ready means of setting a third point on this axis, providing the brightness and colour intensity of the pattern can be maintained at appreciable distances from the double hole.

Optical and Mechanical Design

At the outset an attempt was made to reproduce the apparatus described by van Heel, who replaced the holes by single and double slits. The N.P.L. experimental arrangement is shown diagrammatically in Fig. 2 and consisted of three units. The first of these contained a light source, a collimating lens to provide substantially parallel light and a single slit, the second a double slit and the third an eyepiece with a micrometer controlled graticule. For various reasons the resulting fringes were disappointingly weak and blurred. It was therefore decided that, whilst adhering to the basic principles of the technique, a comprehensive series of tests should be undertaken in which the various factors likely to influence the performance could be varied at will. They included: (*i*) design of slits; (*ii*) type of light source; (*iii*) slit proportions; (*iv*) selection of the setting datum in the fringe field and the appropriate design of graticule; (*v*) magnification of eyepiece; (*vi*) the effect upon the fringe pattern of the disposition of the component parts; (*vii*) effect of external illumination.

The results of these tests enabled conclusions to be reached regarding the preferred form of the component parts of an alignment set, the performance that might be expected of them and possible applications for such equipment.

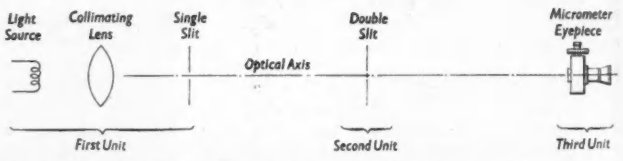


Fig. 2—The N.P.L. Experimental Arrangement for Interferometric Alignment

The three units which comprise the prototype alignment set are shown in Fig. 4 and are, from left to right, the single slit unit, the double slit unit and the micrometer eyepiece. All consist of accurately ground hardened steel cylinders of the same diameter, recessed at one end to receive very closely fitting spigot pieces upon which the slits and micrometer eyepiece are mounted. It is intended that, in use, the parts to be aligned should be designed to receive these units, either by their being entered into a bore, or by being held in a vee-block or angle plate. It follows therefore that, as it is the slits and graticule which are brought into line by observance of the fringe pattern, these parts must be capable of being set in a known relationship to their respective cylindrical bodies, and that the most convenient relationship is with them set symmetrically about the axis of the body. In order to make this setting in the two slit units with a high degree of precision, a fine slit-positioning adjustment has been used. Reference to Fig. 5 will show that the slits are formed by steel strips *A* mounted in a recess on the under side of a parallelogram-shaped block *B*; the block is held in contact with the inclined face *C*, machined on the spigot piece by the spring *D*. The position of block *B* along face *C* may be adjusted by two opposed grub screws *E*. Cover plate *F*, shown

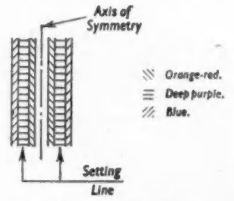


Fig. 3—Fringe Pattern Produced by Interference Bands

removed, closes the box-like enclosure for block *B*. Because face *C* lies at a small angle with respect to the slit, small adjustments of the grub screws will produce very small lateral displacements of the slit. By precise construction of the component parts of the unit, the slit, when set for lateral position, does not lie appreciably off-centre along its length.

When item (*ii*) was considered, lamps of various power and design were tried. The lamp finally embodied in the single slit unit is a 24W close-coiled filament lamp having the filament set parallel to the slit and located at the principal focus of the collimating lens. It had been hoped that mercury-vapour arc lamps (both high pressure and laboratory types) in conjunction with the appropriate filters, producing near-monochromatic light, would provide sharper lines, but the resulting spectra field was not improved in definition as hoped, in fact, rather the reverse.

Under item (*iii*) it soon became apparent that, to maintain adequate colour intensity of the fringe pattern over a working range up to 200ft (61m), it would be necessary to have two sets of slits of different proportions, and it was largely the need to exchange slit assemblies without disturbing their setting in relation to their body axes that led to the adoption of the closely-fitting spigot pieces in the prototype set.

In the early N.P.L. experiments attempts were made to set on the centre of each "setting line" in turn, using first a cross-wire graticule and subsequently a vertical hairline in the eyepiece. It was found that in both cases this led to appreciable variation between individual observers' values for the mean reading corresponding to the pattern centre. It was found more satisfactory to make a single setting, by using a graticule comprising a single bar whose width nearly obscured the central band of light, leaving a crisp orange band on either side. A small displacement of this type of graticule with respect to the centre of the pattern produced a marked out-of-balance appearance of the bordering orange bands; this appreciably increased the sensitivity of setting in comparison with the previous technique which conformed to the method described by van Heel. The central

* Communication from the National Physical Laboratory.

† Van Heel, A. C. S., 1949. "Some Practical Applications of a Precision Alignment Method." *Appl. Sci. Res. B.*1, 306.

setting, which was to be preferred for these reasons, was satisfactorily achieved for a fixed spacing of the double slit unit and the micrometer eyepiece.

However, it is a property of the fringe pattern that it broadens or narrows with changes in separation of these two units, and consequently the optimum width of the graticule strip is a variable quantity. The design shown in the illustration, Fig. 6, was therefore adopted in order to provide this optimum width with a single graticule bar. The micrometer unit is shown with

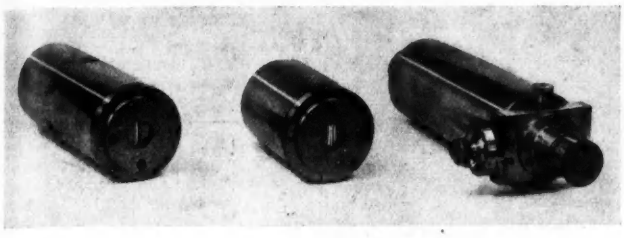


Fig. 4—The Three Units Comprising the Prototype Alignment Set

its cover removed to expose the graticule-carrying slide *A* which is traversed by the micrometer screw *B*, the slide being continuously biased to the left by the springs *C*. The position of the graticule bar in relation to the slideways *D* is read upon the scale *E*, inscribed on the cover, and the drum *F*, which indicate whole revolutions of displacement, and sub-divisions of a 1/50th part of a revolution respectively. One drum division is equivalent to a movement of 0·0005in (0·013mm). The graticule bar is a hardened steel rod which may be rotated about a vertical axis in close-fitting bearings in the slide. Over its central portion it has been ground away to a precise diamond section and Fig. 7 indicates the manner in which the effective width of the graticule bar, as viewed through the eyepiece, can be varied by rotating the bar.

The setting of the slits and graticule bar on the axes of their respective cylinders was made upon a universal measuring machine, fitted with a microscope, by observation of the boundary lines on the cylinders, slits and graticule bar.

With regard to item (*v*), over-magnification of the pattern reduces its crispness of colour and the sensitivity of setting. Normally, a 7× Ramsden eyepiece is suitable for the small and medium ranges, an eyepiece of lower magnification being used with benefit over ranges in the region 100ft-200ft (30m-61m). There are, however, certain limitations in their use which are mentioned later.

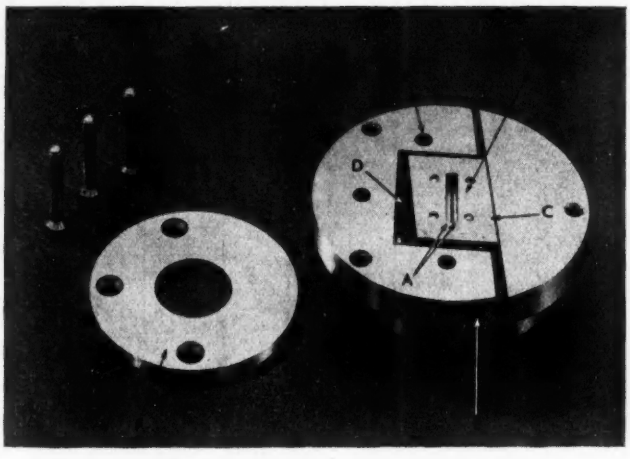


Fig. 5—Details of Slit Positioning Arrangement

The characteristic broadening of the fringe pattern with increased separation of the units has been referred to earlier. Because of the reduced crispness of the pattern which results, it has been found advantageous for the apparatus to be arranged so that the double slit lies closer to the eyepiece than to the single slit, if the intermediate of the three points to be aligned is very appreciably displaced from the mid-position. It further appears that the separation between the single and double slit unit should not be reduced to much less than 10ft (3m) as the balanced appearance of the pattern then becomes unduly sensitive to any error in form of the double slits. The smallest width of fringe pattern upon which settings can be made is determined by the minimum effective width of the graticule, and it has been found in practice that on this account the separation of the double slit and eyepiece should not be reduced below about 6ft (1·8m).

The method can be used in lamplight or dull daylight in the manner described. In normal daylight precautions have to be taken to prevent strong light entering the eyepiece: this is achieved in the alignment set by substituting a pinhole eyepiece for the Ramsden eyepiece. In brilliant daylight, additional precautions are necessary, and take the form of a light alloy tube extending forward from the body of the micrometer eyepiece. The tube, some 3ft long (1m) is blackened, on the inside and, by cutting the end in a plane inclined at 30 deg. to the axis and turning the longer side towards the light, it affords a further measure of shielding. It is used in association with a blackened cowl on the double slit unit of such proportions that it covers the field of view of the micrometer eyepiece when the shield tube is in position.

Checks of Performance

When the alignment set had been constructed along these lines, attention was turned to suitable methods by which its performance could be checked, in respect both of accuracy of repetition and accuracy of alignment. As a preliminary, therefore, observations were made to check the accuracy of repetition and the agreement possible between different observers. The results of these checks were sufficiently encouraging for them to be followed by a self-checking test designed to reveal the accuracy with which the apparatus could estimate the misalignment of three points. Four equally-spaced vee-blocks (say, 1, 2, 3 and 4) were brought approximately into line by an alignment telescope and collimator unit. The units of the interferometric set were positioned in blocks 1, 2 and 3 and a micrometer observation made of their misalignment: the procedure was repeated at 1, 2 and 4, at 1, 3 and 4, and at 2, 3 and 4. From all these observations three values may be deduced for the departure of 3 from the line joining 1 and 4. The lack of agreement between these values has been accepted as a measure of the accuracy of optical alignment attainable with this equipment. It was concluded that an accuracy of alignment of a middle point with respect to a line joining two points spaced up to 60ft (18m) apart, could be easily achieved to within ±0·0003in (±0·0076mm). Under optimum atmospheric conditions in which the brightness, depth of colour and definition of the pattern were sufficiently good, this order of accuracy could be obtained up to 120ft (37m), falling to ±0·0005in (±0·013mm) at 180ft (55m). However, more often than not, difficulty was experienced over the larger ranges due to air disturbances along the optical path which caused the fringe pattern to flicker. Conditions indoors are dependent upon the size and shape of the room and the distribution of the heating system. For example, in a large room with heating pipes round the walls the accuracy over a 100ft (30m) range might fall at least to ±0·001in (±0·025mm).

It may be added here that, to obtain the maximum accuracy when the observer is interested in absolute alignment, it is desirable that

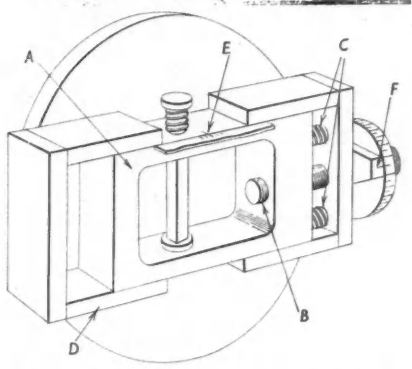


Fig. 6—Design for Providing Optimum Width with a Single Graticule Bar

two sets of readings should be taken, all units being rotated through 180 deg. between sets. This will eliminate the effect of small residual errors in certain features of the equipment, such as the slit positions. This procedure is not necessary when the observer is interested only in variation in the alignment of three points.

Applications

Finally, an alignment set of this type has numerous specialised applications, for example, the alignment of long rail sections such as those employed on model ship testing tanks, in addition to the more obvious uses in large civil constructional work and industries in which large jigs have to be aligned during their assembly.

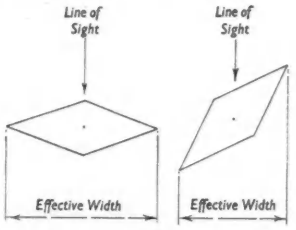


Fig. 7—Variation of Effective Width of Graticule Bar

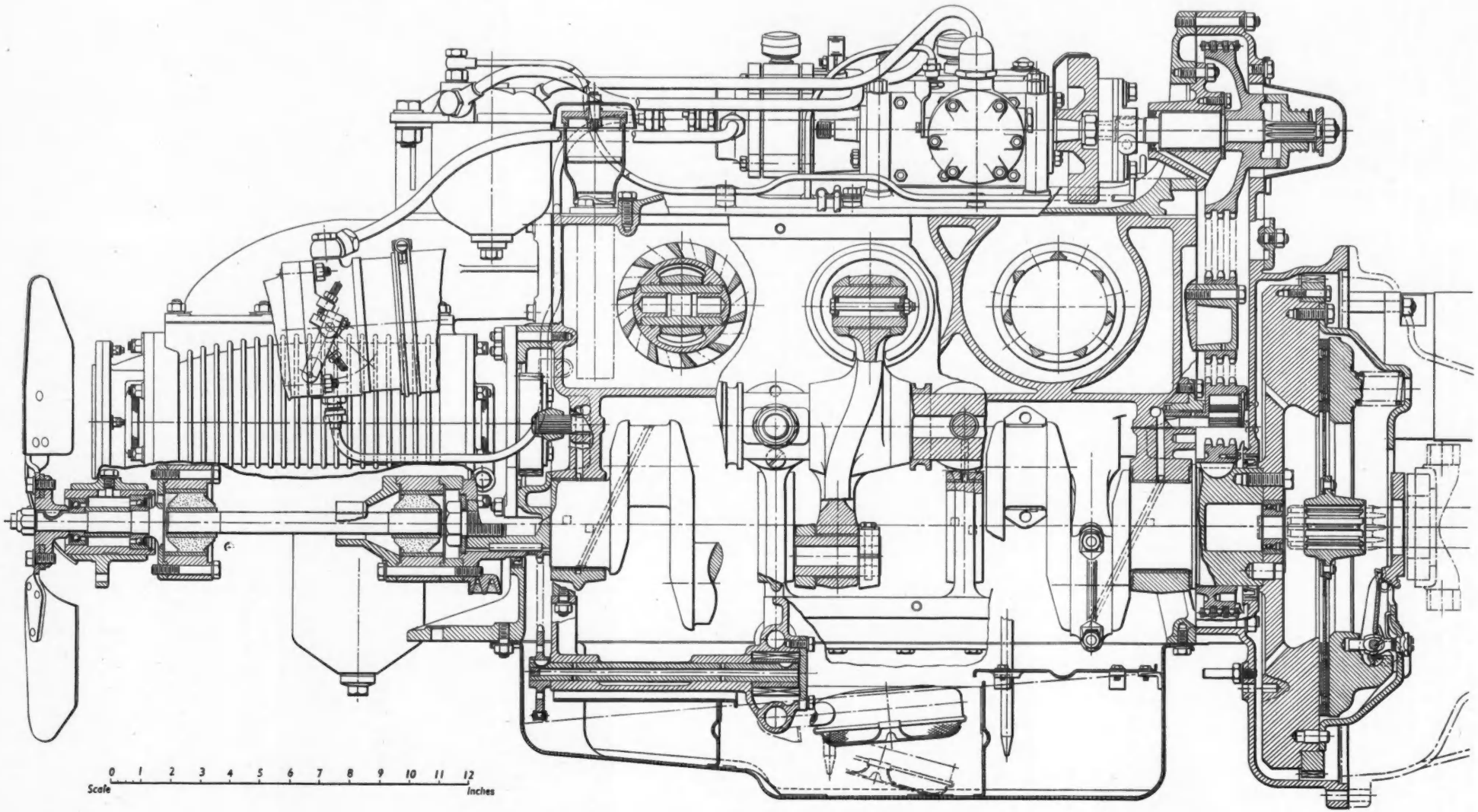
Surfaces can be explored for straightness of a generator by moving one of the three units along the optical axis, the other two units remaining stationary. In fact, the cylindrical form of these units permits them to be rotated to measure misalignment in any plane containing the optical axis.

Acknowledgments are made for help received from Mrs. J. G. Wood, in particular for suggesting the four vee-block method of assessing performance, and to Mr. J. Wilson of Metrology Workshop, who constructed the equipment.

The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this article is published by permission of the Director of the Laboratory.

Hydraulic Puller for Pit Props.—Particulars have been issued of a new general-purpose mechanical handling device, designed primarily to speed up withdrawal of pit props below ground, which is manufactured by A. G. Wild and Co., Ltd., of Sheffield. It is in the form of a manually-operated, double-acting, hydraulic pump, through which a piston-rod is retracted into a cylinder. A pull of 10,000 lb can be exerted by operation of the actuating lever. The machine weighs only 44 lb, and its compact design enables it to be used in confined spaces. A pressure relief valve gives protection against overload on the mechanism. An eye for anchoring is provided at the rear of the device, while the piston-rod has a chain adaptor fitted to its end. With piston retracted the withdrawer measures 2ft 6in overall and its piston has a stroke of 15in.

AUTOMOTIVE OPPOSED-PISTON DIESEL ENGINE



Longitudinal Section Through Opposed-Piston Diesel Engine

Automotive Opposed-Piston Diesel Engine

The automotive diesel engine described is a high-speed, direct-injection, two-stroke unit conforming to the opposed-piston layout. It incorporates a rocker lever linkage driving a single crankshaft, has three cylinders of 3261 cubic centimetres total capacity, and porting based on Kadenacy principles with blower-assisted scavenging. It develops 90 b.h.p. at 2400 r.p.m., and weighs (dry) only 997 lb. The principal advantages claimed for it are its relatively high mechanical and thermodynamic efficiencies and the low cost and simplicity of maintenance.

A DIESEL engine of unusual configuration for automobile purposes has been introduced by Commer Cars, Ltd., Luton. It is known as the "TS3" and is the first diesel engine to be made by the company. At the same time, to suit this engine, the company has modified its "Avenger" bus chassis which will become available with a choice of two wheelbases—15ft 9in and 17ft 6in.

The engine develops 90 b.h.p. at 2400 r.p.m. and has a maximum torque of 250 lb-ft at 1200–1500 r.p.m. Its dry weight is 997 lb.

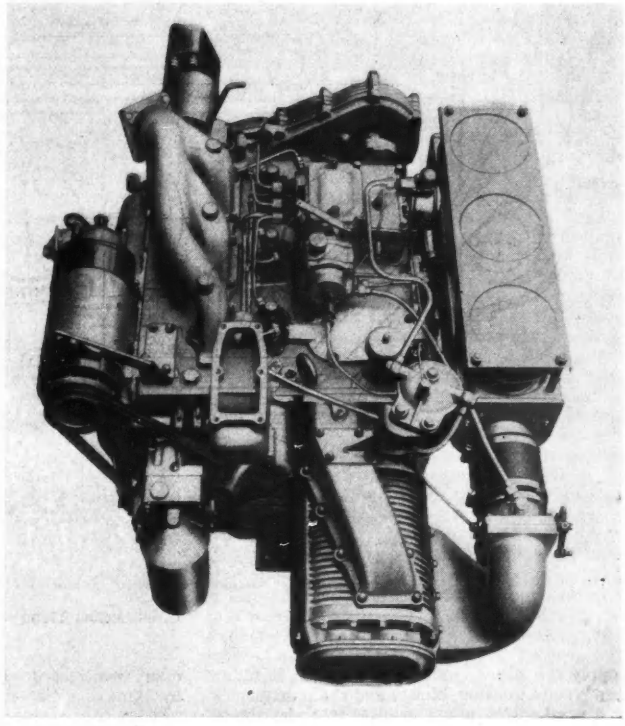
A horizontally opposed-piston layout has been adopted working on a two-stroke cycle with direct injection. External views of the engine are shown herewith, together with general arrangement drawings. There are three cylinders of 3½in bore and 4in stroke, giving a capacity of 3261 cubic centimetres. The crankshaft, which lies centrally below the cylinders, is driven from each piston by a piston-rod and connecting-rod linked through a rocker arm. An advantage of this "beam engine" linkage arises from the small side thrusts imposed on the cylinder walls—the maximum angle made by the piston-rod with the cylinder axis being no greater than 5 deg. compared with the more normal angle of about 17 deg. The cylinder block and crankcase form a single compact iron casting embodying cast iron wet liners which are sealed by flexible metallic lips ground on the outer diameter, thus dispensing with joints and rubber rings. Inlet ports are cast tangentially at one end of each liner and are controlled by one of the pistons, and the exhaust ports, which are machined at the opposite end, are controlled by the other piston.

The design of the engine is based on a principle credited to Michel Kadenacy, which involves the opening of the inlet orifice (25 deg. after the exhaust ports) at the moment when the rapidly outflowing column has been formed and a suction effect is exerted at the inlet port; the products of combustion are cleared rapidly and it is possible to secure high volumetric efficiency in the following air charge. In addition, a "Roots" type "Wade" blower supplies air at a low pressure to the air chest in the cylinder block—the air passing through an oil bath, air cleaner and silencer prior to entering the blower. The blower is arranged to supply one and a half times the piston displacement of air into the cylinder, which, after scavenging, assures an adequate volume for combustion under all conditions. It has a spring-cushioned quill drive from a triple chain situated at the rear of the engine. On starting the engine, and at low speeds, any initial "kick" in the drive is damped out by cushioning the lobes of a cam against spring steel plates.

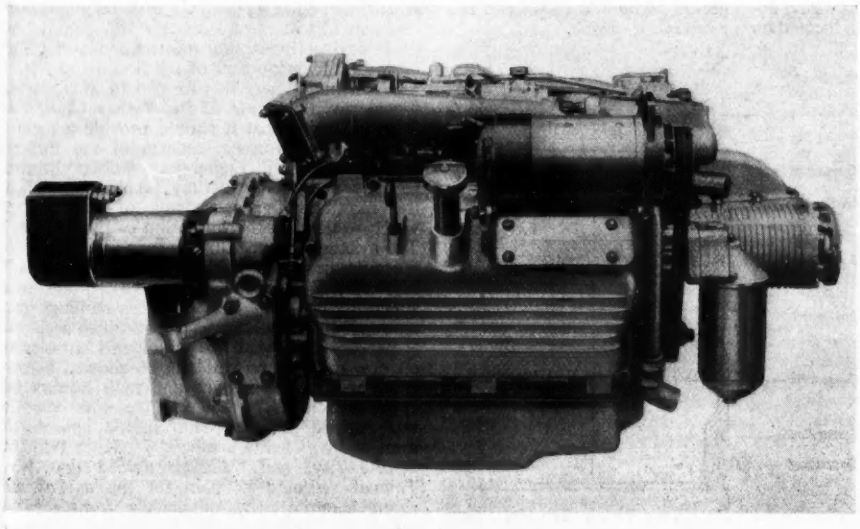
Each piston can be seen from the diagram to comprise a cast iron body rigidly attached to a heat-resisting steel crown. Between them is an insulating plate forming a thermal barrier to minimise the high heat losses through the piston, characteristic of the two-stroke cycle. The face of the crown in contact with combustion is dished to form a near hemispherical shape. Above the gudgeon pin, which is nitrided, and has brass end pads, is a composite fire ring and two wedge compression rings, a stepped air seal ring, and a two-piece scraper ring being carried at the outer end of the piston skirt. Cylinder and piston lubrication is particularly well controlled, and as the scraper rings operate through the completely unworn section of the bore on the outer side of the ports, the life of these parts is claimed to be much improved. The fact that there is no cylinder head to convey heat away from the combustion zone and that a very small element of the water-cooled cylinder is exposed to this zone contributes to the high thermal efficiency claimed for this particular engine.

An alloy steel drop-forged crankshaft is used which has been kept relatively short and is provided with generous journal overlap. It is carried in four thin-wall, steel-backed Babbitt-lined main bearings and is fully balanced. A torsional damper is not fitted. The crankcase is a one-piece iron casting with web stiffening.

The two rods by which each piston is connected to its rocker arm have forked ends to engage the arm, the arms being balanced in pairs. Due to the opposite-acting connecting-rods, side loads on the crankshaft are in almost perfect balance, and consequently the main bearings are only lightly loaded. As there is no load reversal on the connecting-rod bearings, the more highly loaded upper section is in copper-lead indium, whilst the lower section is of Babbitt.



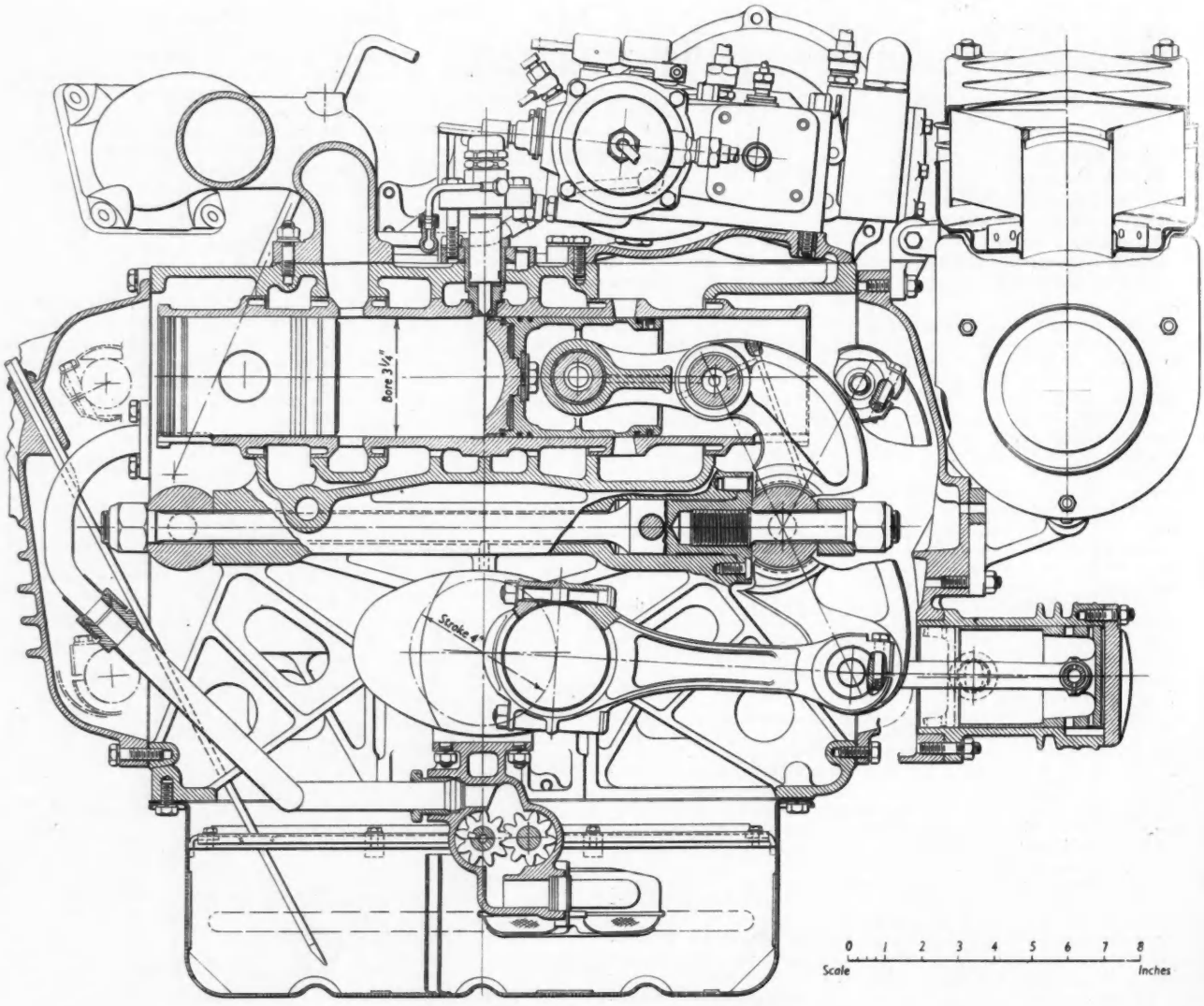
Engine Showing Layout of the Fuel Equipment, Air Cleaner and Silencer, Roots Blower, Dynamo and Exhaust Manifold



95 B.H.P. Two-Stroke Diesel Engine with Horizontal Opposed Pistons, Direct Injection and Blower-Assisted Scavenging

Injection Equipment.—Embodied in the three-cylinder C.A.V. "N" type pump is the fuel lift pump, the drive of which, via an adjustable coupling, is from a triple chain situated at the rear of the engine. A pneumatic governor is brought into action by a venturi unit built between the air filter and blower unit. Fuel filtering has received special consideration and consists of a combined dirt and water trap between the fuel lift pump and tank, a fine gauze screen in the lift pump itself, a C.A.V. paper element filter on the delivery side and felt block filters in the injection pump. The injectors are of the single-hole design and operate at 140 atmospheres.

Lubrication and Cooling.—A single chain at the front of the engine drives a gear pump which supplies the main galley through a full-flow filter. Before entering the pump, lubricating oil is strained by means of a floating filter. Branch drillings from the main gallery supply the main bearings, and oil is relayed via the hollow rocker shafts to the rocker centre bearings and to the top and bottom end bushes. The gudgeon pin is intermittently fed through a drilling in the piston-rod, whilst further drillings and pipes



Cross Section Through Opposed-Piston Diesel Engine

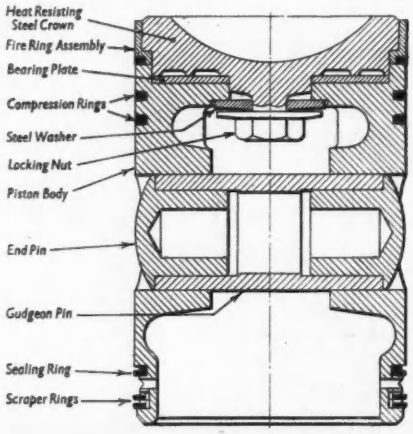
supply the blower unit drive housing, injection pump drive housing, blower and chain drive.

An exhauster pump is built into the engine to maintain vacuum in the oil reservoir. It is located on the air side cover, and works on the "two-stroke" principle, having ports in both cylinder and piston. Its reciprocating motion is obtained directly from one of the main rocker levers. Cooling is maintained by a centrifugal pump, having self-adjusting gland and running on sealed ball bearings, in conjunction with a 17in diameter five-bladed fan, which together give vigorous water and air flow through a tubular radiator block located under the cab floor. A by-pass thermostat regulates engine heat and gives unrestricted circulation at 85 deg. to 89 deg. Cent.

Clutch and Gearbox.—An enclosed 13in diameter single dry plate clutch and iron alloy flywheel is fitted with withdrawal gear of the ball bearing design. Engine and clutch form a unit with the four-speed gearbox, in which high-duty alloy steel gears are carried by short stiff shafts on ball and roller bearings in a compact cast iron case. Constant mesh helical gears are employed for third gear, whilst top gear is of conventional direct drive. Remote control selector mechanism is mounted in a full forward position on the engine. The complete power unit is mounted in the frame on three special rubber mountings—sandwich pattern at the front and heavy-duty "Metacone" at the rear.

Maintenance.—One of the principal advantages claimed for this engine configuration is the simplicity of maintenance. The engine is particularly suitable for "under floor" applications and is designed to make possible engine servicing, repair and maintenance *in situ*. Access to the main rocker, bearings, pistons, &c., is possible by removing the engine side covers, and the pistons can be serviced without removing the engine from the chassis.

It is maintained that due to the exhaust port design "coking-up" is very limited and that to a major extent the ports are self-cleaning. Full access to the ports is obtained by removing the exhaust manifold and without removing the pistons. The injector pump and auxiliaries are all located on the top of the engine.



Section Through Hot Crown Piston The Hot Crown Causes the Fuel to Burn Immediately it Enters the Combustion Chamber and to Continue to Burn Evenly Throughout the Complete Injection Period

Society of Engineers' Centenary

THIS week, the Society of Engineers is celebrating the centenary of its foundation. It is the third oldest national engineering society in Great Britain, and ever since it began has concerned itself with the interests of engineers in all branches of the profession. This year's president of the Society is Mr. W. R. Howard, and his presidential address, to which brief reference was made in our issue of February 5th, contains a great deal of interesting information about the origin and development of the Society.

When the Society was formed in May, 1854, it was given the title of the Putney Club, the intention being that it should provide a means of reunion of former students of the Putney College for Civil Engineers. Robert Monro Christie and Henry Palfrey Stephenson called the meeting of past-students of the college which resulted in the formation of the "Club." The meeting, attended by six men in addition to the conveners, was held at "Mr. Talmadge's," No. 221, The Strand, The subscription was stated to be "not exceeding ten shillings per annum" and a by-law was passed which declared "that the club shall be adjourned at eleven o'clock and that no smoking be allowed before nine, and that spirituous and malt liquors be entirely excluded." Later in the same year it was decided that the Club should henceforth meet at Mr. Christie's offices, 76, King William Street, City, and "It was agreed that Mr. Talmadge should be paid for the use of his room heretofore by purchasing from him a pound of cigars to be retailed out to the members." The custom of reading and discussing papers appears to have started in 1855, the first

paper being one by Mr. H. P. Stephenson on "The Rise and Fall of Putney College."

The decision to change the name from the Putney Club to the Society of Engineers was taken at the annual general meeting in December, 1857. One of the sponsors of the new name was a Mr. Charles J. Light, who became secretary of the Society thirty years later. At the same meeting, it was decided that the meetings should be held at Exeter Hall. In the following year, 1858, the membership of the Society totalled 107, and with Mr. R. M. Stephenson as president, the Society introduced the awarding of premiums of books in recognition of outstanding papers. The first awards were to Mr. James Amos for his paper entitled "The New Hydraulic Lift of the Thames Graving Dock" and to Mr. John Glynn for a paper on "Dr. Clarke's Water Softening Process." By the time the Society of Engineers had completed its first five years its membership numbered 169. At the same time, in 1859, a group of pupils and draughtsmen at Radcliffe in Lancashire started the "Civil and Mechanical Engineers Society." Most of the early members of this society appear to have been marine engineers, but as the years passed many of its members came from various branches of railway engineering. The late Mr. A. S. E. Ackermann became secretary of the Civil and Mechanical Engineers Society in 1898, and in 1907 he took up, in addition, the secretaryship of the Society of Engineers. Three years later, in 1910, there was a fusion of the two societies, the full title becoming "Society of Engineers (Incorporated)." In January, 1951, new articles and by-laws were approved by the Board of Trade, following the adoption of a scheme of examinations for those desirous of becoming members of the Society. There are now four classes of corporate membership and three classes of non-corporate membership. The present membership of the Society of Engineers is representative of many overseas countries in addition to the United Kingdom, and the papers and lectures delivered at its meetings deal with all aspects of engineering development. The Society has a number of medals and premiums which are awarded annually in respect of papers or work deserving of special recognition.

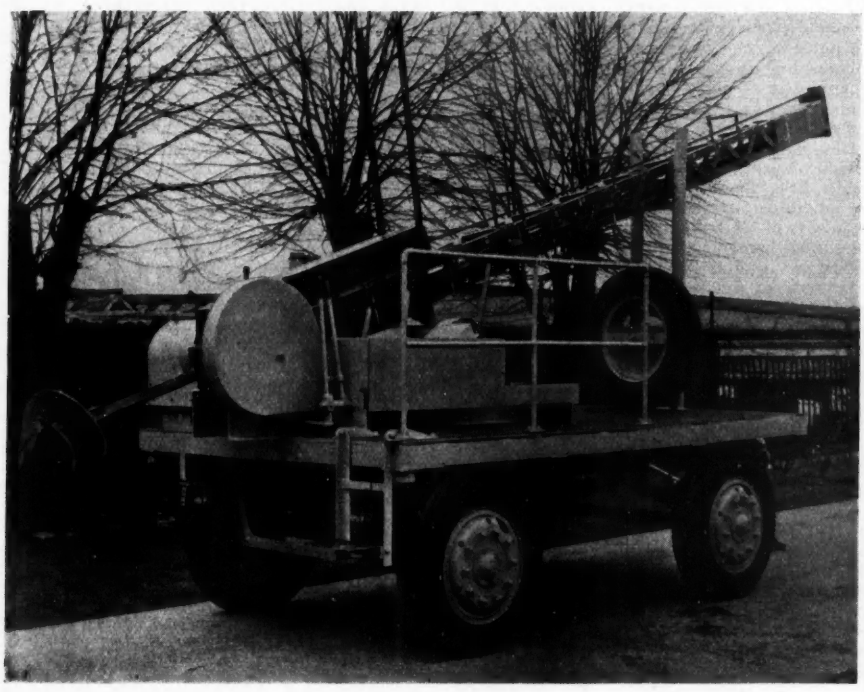
The centenary celebrations in London this week included a special meeting at which papers dealing with progress during the last one hundred years in civil, mechanical, electrical and aeronautical engineering were presented by Sir Murdoch MacDonald, Mr. George Constantinesco, Sir Robert Watson-Watt and Sir Roy Fedden. This evening, there is to be a centenary banquet at Fishmongers' Hall, London Bridge, at which the Churchill Gold Medal, awarded for the most noteworthy contribution to contemporary engineering, will be presented to Sir William Wallace, for his work in the development of ship stabilising gear.

Soil Boring Machine

THE soil boring machine, which is illustrated on this page, is now being put into production by Le Grand, Sutcliff and Gell, Ltd., Southall, Middlesex. It is based on a design prepared originally by the Road Research Laboratory of the Department of Scientific and Industrial Research, to which some reference was made in THE ENGINEER of December 19, 1952. The machine as now developed is capable of boring vertical holes, in most soils, including gravel and clay, to a depth of 16ft and up to 20in in diameter. At a demonstration last week it was shown also that the machine can bore holes at an angle up to about 30 deg.

Our illustration shows the machine assembled on a trailer in its transport position. It is built on a steel channel base frame, 7ft long by 4ft 10½in wide, the square steel boring bar being housed in a welded steel lattice mast which is raised by feed screws to a height of 20ft 9in. Double helix or flat plate boring tools can be used, a 12in diameter double helix being the "general purpose" tool recommended by the makers. A Petter air-cooled twin-cylinder diesel engine, developing 8 h.p. at 1200 r.p.m., provides the power for the machine. Transmission is through duplex chain and spur and bevel gearing, the main drive from the engine being taken by four "B" section vee belts, a slipping device being incorporated to protect the mechanism from damage arising from any sudden stoppage of the boring tool. The boring bar passes through a central square hole in a clutch-controlled gear wheel, and is steadied at its upper end by a bearing which is free to slide inside the mast. The bar is attached to an endless chain which passes over a free sprocket at the top and a driving sprocket at the bottom of the mast. A hand brake is fitted to permit gravity feed. Each of the drives—mast raising and lowering, tool raising and lowering, and tool rotating—is reversible, there being three clutch levers and one combined clutch and brake lever for operating the machine.

In operation the machine is placed with the mast centred over the required boring position. The mast is then raised from the travelling to the boring position and the tool is lowered to ground level. The rotating gear clutch is engaged and boring begins, and after a short distance has been bored the rotating gear is stopped, the tool lifted and rotated above the surface to throw off the spoil removed from the hole. This sequence of operations is repeated until the required depth has been reached. The normal speed of rotation of the boring tool is 80 to 100 r.p.m. and the average boring rate is 1ft a minute. The mast is graduated at intervals of 6in so that the depth of the tool from the surface may be determined by the operator, and an inclinometer is fitted to measure the angle of drilling.



Soil Borer in Transport Position

Junior Institution of Engineers

THE annual dinner of the Junior Institution of Engineers was held in London on Friday last, April 30th, when, owing to the absence of the president, Sir John Hacking, the chair was occupied by Air Commodore F. R. Banks. In proposing the toast of the Institution, Mr. D. M. Watson praised its work in bringing together the enterprising younger engineer and the experienced older engineer. He said that progress in a large measure depended upon the initiative of the younger man in taking advantage of new techniques and processes, whilst the mature judgment and experience of the older man provided the necessary background. In replying, Mr. S. G. Clark spoke about the opportunities for advanced learning the young engineer and technician of to-day had, as compared with those of the previous generation. Mr. T. Graeme N. Haldane proposed the toast of "Electricity and the Future" and after dealing with the growth of the use of electricity in this country, said that it was certain that the amount of coal available would not be enough to supply the requirements of the generating plants in fifty years. Nuclear fission would probably be the solution to this problem although how it would be applied he was not yet sure. Mr. Haldane pointed out that there was great concern at the moment in applying new techniques, but he felt that greater attention should be paid to developing men and engineers. Mr. E. A. Mills replied to the toast. The toast of the guests was proposed by Mr. A. S. Ladley, and Mr. H. Bishop responded.

Conference on Work Study

PART of the Organisation for European Economic Co-operation is concerned with work study. This particular activity is dealt with by a working party which reports to the O.E.E.C. productivity and applied research committee, which committee, in turn, makes recommendations to the European Productivity Agency. In its programme, the working party arranges, at approximately half-yearly intervals, international gatherings which are attended by representatives from various European countries with a special interest in work study. The Department of Scientific and Industrial Research is associated with this activity, and in co-operation with the council of the Institution of Mechanical Engineers an informal seminar on the subject of work study was held in London last Wednesday. This seminar, which was held in the Hall of the Institution of Mechanical Engineers, was attended by overseas visitors and by selected people in this country with particular interests in work study. Major-General W. A. Lord, Director of Mechanical Engineering at the War Office, presided, the general discussion being based on five short introductory papers. The seminar was preceded, on Tuesday evening, by a general meeting of the Institution of Mechanical Engineers, at which a paper on "The Scope and Development of Work Study" was presented by Mr. R. M. Currie, head of the central work study department of Imperial Chemical Industries, Ltd.

Metallurgical Topics

Alloy Steels and Powder Metallurgy

By H. W. GREENWOOD*

ALLOY steels have a special interest for the engineer and for the powder metallurgist. They offer many possibilities of special properties and hence of special service, but though there is quite a literature on the subject it is largely uncoordinated. Even a cursory examination suggests many interesting possibilities, particularly as the range of properties available and even more the promise of better control of those properties is most attractive in these days when progress is calling for materials which in practically all important qualities will transcend anything that we have been familiar with in the past. The more these modern requirements and their limitations are considered the more difficult the problems that emerge.

Most frequently they are of a fundamental character that calls for research work of a high order, and often the findings so far arrived at provide us with a further set of problems even more abstruse than those that have been at least partially solved. That is the impression left with the metallurgist, who is usually called upon to indicate materials having the strength and other properties that will fulfil the engineer's requirements and also fall within his factor of safety. It may well be that the metallurgist will be called upon, or at least find it necessary, to suggest means whereby currently available materials may be given such increased good properties that they will rather more than pass the engineer's factor of safety. So soon as one attempts even a preliminary survey of the subject, difficulties are encountered. As an example, both engineers and metallurgists are aware that the properties of metals are tremendously dependent upon the purity of those metals. The physical properties, and even chemical properties, are most profoundly affected by the presence of impurities, so small in actual quantities that only a few years ago they would have been completely ignored or considered as traces only. What is also of consequence is the fact that the presence of quite small amounts of impurity may be as much an advantage in some cases as it is a disadvantage in others. One effect of this condition of affairs is that it is becoming increasingly necessary to treat each important demand for a particular metal or alloy as a special problem in itself, in which, as nearly as is possible, the exact qualities essential to a thoroughly effective performance of the particular job can be guaranteed. It is due to this aspect of the matter that we hear about "tailor-made" metals and "custom-built" alloys. To-day these terms may apply to ferrous or non-ferrous metals, but in the case of ferrous metals it is fairly certain that it will be alloy steels that are involved. Considering that alloy steels have been known at least since Faraday's time, it must be obvious that metallurgists, to a great extent, have been content with almost wholly empirical knowledge. Only by admitting some such conclusion can we explain how very many important questions still await adequate answers. Such a point of view might well have evoked surprise and unbelief only a comparatively few years ago, but to-day the requirements of both engineer and metallurgist are of such an order that every possible means of study and analysis are necessary if we are to perfect our control of metals so as to meet adequately to-day's requirements. In this connection powder metallurgy has an immensely important part to play, for powder metallurgical operations provide the most suitable and often the unique means for producing the materials required, and for studying their behaviour, and the effect of small additions to their composition and of small variations in their treatment. Furthermore, experiment with powder metallurgy is rapid and economical both in materials and in plant, while recent developments in technique have opened up possibilities of great interest and importance. Attention may be specially directed to the possibilities of offering alternative materials, or alternative treatments of materials, which can by-pass some difficulty and by a change in technique offer a material capable of passing the required specifications or even somewhat surpassing them. It would appear possible that in considering requirements in special steels there has been a tendency to attempt the solution of a single problem, or to produce a single material, without considering whether it would not serve better to aim at an understanding of general and guiding principles and so gain a broader insight into the basic mechanisms of metal and alloy behaviour, as well as a practical knowledge of the effects of this or that addition to materials. It is common knowledge that increase of carbon content in unhardened steels means increase in tensile strength and elastic limit, while at the same time ductility tends to fall. Many engineers have questioned whether, where service stresses are mainly static, present practice does not tend to keep the carbon content of steels used for such work unnecessarily low. This is equivalent to asking whether specifications to-day do not err in demanding high elongation per cent and it has been stressed by members of the Iron and Steel Institute Alloy Steels Research Committee[1] that excellent results have come from the addition of 0·2 per cent of aluminium to structural alloy steels of high phosphorus content. This, too, as far back as 1936. There is evidence that the addition of quite small amounts of copper can bring about age-hardening effects of appreciable magnitude. Whilst it has been generally observed that, in making additions of different elements in small quantities to steels, a greater hardening effect is obtained by using a number of different elements than by using the equivalent quantity of one only, there is as yet too little knowledge of actual effects and an obvious want of much further investigation which would be of the highest practical value. There is a small, but worthwhile, field of investigation in studying the effect of additions of metals that can reduce the solubility of age-hardening elements and so bring about age-hardening with much smaller amounts of copper, or other element having similar action, than has so far been used, thus allowing of saving of metals in short supply. These are but some of the more familiar examples of producing special steels by materials and methods that offer greater control and a wider range of special properties than have so far been available. A cognate subject is the boron steels, about which there exist already a considerable literature and also a large collection of loose ends of investigation which some day will have to be tied up and, at least to some extent, verified and amplified.[2,3] An obviously valuable field is that of the austenitic chromium-nickel and allied alloys, on which useful improvement of high temperature oxidation resistance has been attained by addition of very small quantities of cerium or of misch-metal. Cases have been cited[4] in which the life of wire, of 0·4mm diameter, of a chromium-nickel-iron alloy held at 1050 deg. Cent. was increased from 75 to 350 hours by the addition of 0·11 per cent misch-metal, and the addition of 0·39 per cent misch-metal increased the life to 1100 hours. Much work along these lines has been carried out in the United States. An example published in the fall of last year[5] dealt with the transformation of inherently hot-short, high-alloyed austenitic stainless steels into ductile alloys by the addition of small amounts of cerium or lanthanum in the form of misch-metal. In the case of inherently ductile austenitic stainless steel the addition of oxides is claimed to improve the workability and surface characteristics of the steel, but as the oxides leave no trace of the metal in the steels they do not affect hot-short grades. Although many of the results obtained by various additions of small quantities are contradictory, or at least difficult to reconcile one with another, there can be no question as to their interest and value. It also appears that in almost every case reported, although useful results were obtained, investigations were rarely, if ever, carried to a final conclusion. In fact, it would appear that so soon as an experiment or two had provided a result apparently favourable, no further investigation was carried out. As a result, so long as the immediate effect was obtained and proved reasonably satisfactory, no further work was done; and so in many cases we are left with the information that such and such an addition will do so much, but we are not able to say whether a minimum or a maximum was reached and so cannot exploit the result to the best advantage without much further work. This is particularly noticeable in the various investigations with age hardening. There is quite a good deal of use made of copper as an inducer of age hardening in steels and the practice is growing, but it would be nice to feel that there was neither doubt as to quantity, nor ambiguity as to what happened, when copper was added to steels containing other elements in very small amounts. Information of this kind is of great importance when questions of control arise and also when it is desired to reduce the consumption of expensive materials to as low a figure as possible. In addition to much work of the kind mentioned, there is also another series of subjects about which much more information would be most welcome. It applies not only to alloy steels, but to other groups of alloys and metals, and it can lend itself particularly to material produced by powder metallurgy. It is the solution of the problem as to how far the impact test, so beloved of many inspectors of supplies of metals and alloys, is really so clear an indication of the danger of shock stresses as is believed. It has been suggested that while a simple tensile stress may be resolved into a shear stress and a second tension normal to the shear plane, can the normal tension across the surface be neglected, as is so often assumed, especially in view of the atomic structure of metallic crystals? There are many other questions to which an answer is eagerly awaited. A comparison, for example, of the amount of copper dispersed in iron and the degree of age-hardening it can induce, with the effect produced by copper used as an infiltrant into an iron or steel porous compact. Reasonably exact information on this and similar cases might lead to important economies as well as better and more consistent results. Various anomalies in iron and steel at little above room temperature might well provide valuable information if investigated, and some light might well be shed on the strange failures that from time to time occur at temperatures up to 250 deg. Cent.

Another likely investigation would be the determining of the minimal addition of a particular constituent to bring about some desired effect. Work in the past has shown on quite a number of occasions that a particular effect calls for much smaller quantities of an element than had been thought necessary, and cases are known where the use of more than a sufficient quantity has introduced difficulties and conferred disadvantageous properties instead of the benefits that were expected. From a variety of sources there has been published work indicating the important role that oxides can play in rendering some metals more easily drawn into wire, in inhibiting grain growth and in otherwise modifying metal and alloy behaviour. It is very clear that in all these directions there is a tremendous field for further investigation and one that almost certainly promises outstanding rewards. From work already done it has been demonstrated that we have often used very much larger quantities of additions than were called for, and in that direction alone most substantial savings of material are possible with the added advantage of producing materials having enhanced desirable properties. The field of alloy steels offers a most advantageous opportunity for the much wider development of work of this description and certainly the promise of producing alloy steels calling for much smaller quantities of special alloying metals than have been thought necessary in the past. Few to-day can doubt that alloy steels are destined to play an increasingly important role and, as has been pointed out, the production of alloy steels by powder metallurgy not only offers manifold advantages, but in many cases is the only method

* Powder Metallurgy, Ltd., London.

that can supply steels of compositions including materials other than metals and metallic combinations. The use of oxides and other compounds is capable of endowing such mixtures with improved physical properties, and in particular with enhanced resistance at high temperatures to corrosion, oxidation and other causes of metallic deterioration. The successful introduction of most of these oxides and other compounds must make use of powder metallurgical techniques and the investigation of the changes that such additions bring about, and the close control of the properties they can induce, is also possible only by powder metallurgy.

REFERENCES

[1] J. H. Andrew and D. Swarup, Iron and Steel Institute, First Report Alloy Steels Research Committee, 1936, Section XII, page 227.
[2] C. Sykes, *Metallurgia*, 1953, Vol. 47, pages 3–8.
[3] R. Wilcock, *Iron and Steel*, May 14, 1953, page 215.
[4] THE ENGINEER, September 26, 1952, Vol. 194, page 417.
[5] *Materials and Methods*, September, 1953, page 194.

High-Strength Low-Alloy Steels

IN *Materials and Metals* for February, 1954, there is a comprehensive article dealing in detail with American high-strength low-alloy steels, their general characteristics, corrosion resistance and applications.[1] Composition and mechanical properties of ½in plate in the hot-rolled condition are given for eleven typical materials which fall within the American Iron and Steel Institute's definition of high-strength low-alloy steels as a "specific group of steels with chemical compositions specially developed to impart improved mechanical properties and greater resistance to atmospheric corrosion than are obtainable from conventional carbon structural steels containing copper." These American high-strength low-alloy steels are proprietary products, the compositions of which do not conform to any specified standard. Being proprietary products, marketed under trade names, they differ widely from one another in analysis, but depend usually on the addition of small amounts of any of the elements manganese, silicon, phosphorus, copper, nickel, chromium and molybdenum, in total amount varying from 1 to 3 per cent. These elements may improve the strength of the steel in two ways, either by producing a finer structure or by dissolving in the ferrite and so strengthening the ferrite matrix. The finer structure may be the primary cause of the increase in strength in some of these alloys, and the recognition of this fact may account for the occasional addition of well-known grain-refining agents, in one case of 0·12 to 0·27 per cent of aluminium (in the Inland Steel Company's Hi-Steel) and in another of 0·05 to 0·15 per cent of zirconium (in N-A-X Steel made by the Great Lakes Corporation and the Republic Corporation). The composition is often varied to meet special requirements, but in most cases the carbon content is kept below a maximum of 0·13 per cent. This renders the steel more easily weldable and reduces the risk of air hardening after welding. It also facilitates cold-forming operations. Such steels are readily formable to any shape that can be made from ordinary mild steel, but on account of their greater strength they require higher pressures in cold forming, and they spring back on release of pressure to a greater extent than the weaker steels. As the composition is left to the maker, the steels are supplied to mechanical requirements, usually a yield strength (for ½in plate) of 50,000 lb per square inch (22·3 tons per square inch) with an elongation of 22 per cent on 2in or 18 per cent on 8in. Although their elongation is rather lower than that of ordinary mild steel, they exhibit a considerably greater notch toughness and retain a good impact value to a lower temperature. Their tensile strength varies from 70,000 lb per square inch (31·25 tons per square inch) to an upper limit of about 90,000 lb per square inch (40·2 tons per square inch). These mechanical properties may be compared with the limits laid down for ½in plate in British Specifications for High-Tensile Structural Steels, viz.:—

B.S.S.	S.T.A.S	Yield, tons/square inch min.	Tensile strength, tons/square inch	Elongation, per cent on 8in min.
548	V6	23	35–43	18
968	V6A	23	35–43	18
—	V6B	18·5	30–36	20

For steel over 1in thick the yield strength requirement is reduced to 19 tons per square inch. The composition is not specified in B.S.S. 548, but in B.S.S. 968 and V6A and B there is some restriction in composition for welding quality steel suitable for cold forming.

The chief merit of the steels is the possibility they afford of reduction in weight. Their strength/weight ratio is not equal to that of aluminium alloys or stainless steel, so that when weight saving is of prime importance (as in aircraft construction) they cannot compete, but the transport industries absorb half the production of high-strength low-alloy steel in America, and their earliest applications—to railway freight and passenger cars, wagons and trucks, and other rail and road transport vehicles—continue to provide the chief market for these steels. The steels are also used for structural purposes, bridges and general building construction, and for welded structures and in marine engineering. A table of design data is given in the paper referred to.[1] A moderate estimate of saving in weight made possible by the use of these steels would be about 25 per cent, but for some purposes in which rigidity is an important requirement the actual saving is reduced to 15 or 20 per cent. In such case, however, though the saving in material is lessened, the actual saving in freight charges may be considerable if the fabricated parts have to be transported long distances to the site of erection.

The advantages claimed for the American low-alloy-structural steels are by no means limited to their high strength. Corrosion resistance, in various degrees, is a feature of most of these steels, and is regarded as important on the grounds that the use of thinner sections carries with it the necessity for a resistance to corrosion superior to that of ordinary mild steels. The presence of small amounts of copper in ordinary carbon steels was at one time thought to confer remarkable resistance to corrosion, but though some improvement was noted under ordinary atmospheric conditions the copper-bearing steels showed no advantage in severely corrosive atmospheres or when submerged in water. The beneficial effect of phosphorus, especially in conjunction with copper, was recognised in the development of one of the earliest of the American low-alloy steels, Cor-Ten. The use of this steel in transformer equipment has recently been described by M. M. Aronson.[2] Several American high-strength low-alloy steels now contain phosphorus up to 0·15 per cent, but for the phosphorus-bearing and some other high-tensile steels the most that can rightly be claimed is a substantial increase in resistance to ordinary atmospheric corrosion. They form a more uniform and more adherent type of rust which is practically free from scaling. They are also stated to take paint or other protective coatings better than ordinary mild steel, and so to be more economical in upkeep. In spite of the claim that copper-phosphorus steels have four times the atmospheric corrosion resistance of mild steel, it seems doubtful, in view of conflicting evidence, whether corrosion resistance should be a main objective in the development of these steels.

In British practice the primary objective has been strength, and high-tensile structural steels have usually been developed from carbon-manganese steels by additions of nickel, chromium and molybdenum in amounts such that the total alloy content, including the manganese, does not exceed 2 per cent. The alloy additions, other than manganese, tend slightly to improve resistance to atmospheric corrosion. Copper has not been a popular addition, except possibly in steel castings; and to have a pronounced effect on strength through precipitation hardening the copper content must be at least 0·7 per cent, a figure which is exceeded in several of the American steels.

It is probable that high-tensile steels in the form of plate and sections will have increasing use, not only in the transport industries but in building construction and bridge building, especially in the construction of long-span bridges. Within the B.S. Specifications 548 and 968 the steel maker can make use of such variations of composition as will meet the special requirements of the user. The restrictions in composition included in B.S. Specification 968 are necessary to ensure that the steel is sufficiently free from a tendency to air-harden; but in the pursuit of higher tensile strength coupled with adequate ductility, it is probable that the maximum advantage cannot be gained without provision for subjecting the hot-rolled or normalised steel to a tempering treatment.

REFERENCES

[1] "Materials and Metals Manual, No. 102," *Materials and Metals*, February, 1954, pages 117–132.
[2] "High-Strength Low-Alloy Steel for Transformers," *Materials and Metals*, January, 1954, pages 134–136.

Zinc Coatings

AN article entitled "The New Look in Galvanised Steel," by E. W. Horvick* of the American Zinc Institute, is a reminder of the changes in methods of galvanising which have resulted in a much more versatile zinc-coated steel than was formerly available. A zinc coating protects steel by electro-chemical action. Rusting at bare spots or cut ends is avoided as long as enough zinc remains to be attacked preferentially. When sustained protection is needed, the zinc coating must be fairly heavy and may be subjected to some further protective treatment such as Bonderising or painting.

In hot-dip galvanising, the reaction between molten zinc and steel results in the rapid formation of alloy layers of a brittle character, their thickness and structure being dependent on the composition of the molten metal and of the steel, and on the temperature and time of immersion. Adhesion of the zinc coating decreases as the thickness of the alloy layer increases. Good ductility requires that the growth of the alloy layer should be inhibited or completely avoided.

To satisfy the demands of present-day industry hot-dip galvanised steel has had to meet new standards of corrosion resistance, workability and surface quality. The zinc coating must be thick enough and uniform enough to protect the steel against corrosion for a long period, and must be sufficiently adherent to withstand a considerable degree of deformation. At one time, steel with a heavy zinc coating could withstand only a very limited amount of cold forming without flaking and peeling. When severe deformation was required, thin coatings were applied and either protection had to be sacrificed or the products had to be regalvanised after fabrication to provide thicker coatings. In the continuous galvanising process, close temperature control, together with shorter immersion times and controlled aluminium additions, limit the formation of the undesirable alloy layers, thus removing a source of brittleness, improving ductility and reducing the tendency of the coating to flake during cold deformation. The continuous galvanising line thus makes it possible to produce deep-drawn products with as high a degree of corrosion resistance as flat sheet or strip.

One of the most important developments in the production of zinc coatings is the electro-galvanising process, whereby zinc deposits of approximately the same protective value as hot-dip coatings of equal thickness are produced without any brittle alloy layer, and without the application of heat which may affect the properties of the underlying steel. The process gives a uniform deposit having a smooth surface which is well adapted to receive further protective treatment, if necessary, by enamelling, lacquering, varnishing, &c. Bright zinc deposits of attractive appearance can also be obtained by the addition of suitable organic compounds to the zinc sulphate bath. An important application of electro-galvanising is in the manufacture of zinc-coated wire. Other applications are usually designed to overcome manipulative difficulties or meet special requirements, as the process is more expensive than hot-dip galvanising.

ATOMIC ENERGY APPOINTMENTS.—The Department of Atomic Energy announces that Mr. K. B. Ross, who until 1951 was general refineries manager for the Anglo-Iranian Oil Company at Abadan, and has since then been on the board of Costain-John Brown, Ltd., has been appointed director of production in the Department's industrial group at Risley. Mr. P. T. Fletcher, chief engineer of the Ministry of Works, has been appointed deputy director (engineering services) in the Industrial group. Both appointments take effect from June 1st.

* *Materials and Methods*, March 1954, page 107

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IRON AND STEEL

The annual report of the British Iron and Steel Federation, which was published recently, is a useful record of the progress made by the iron and steel industry last year. The facts and figures set out in it emphasise—if such emphasis be necessary—the wisdom and foresight of this country's iron and steel industry in deciding to go ahead, immediately after the war, with a huge programme of reconstruction and development. That decision, it will not be forgotten, was taken at a time when the future ownership of this major industry was uncertain. Throughout the years of debate on the subject of public ownership, work proceeded on the development schemes set out in the 1945 programme. New plant, representing many millions of pounds of capital investment, has been completed, with the result that British steel output last year at 17,600,000 tons, was higher than it had ever been before. The brief period of public ownership of the iron and steel industry had no deleterious effect upon its output. Even though, by Act of Parliament, they no longer owned their businesses, managements of iron and steel-making concerns maintained the efficient administration of their several undertakings, with labour relations continuing at that high standard of harmony which has been characteristic of the industry for so many years.

Last year, it may be hoped, marked the end of uncertainty about the future ownership of, and measure of public control over, the British iron and steel industry. The Iron and Steel Board, which was set up under the provisions of the Iron and Steel Act, 1953, began, in July, its duty of "exercising a general supervision over the industry," and the Iron and Steel Holding and Realisation Agency started on its task of returning the nationalised companies to private ownership. That turn in the affairs of the industry coincided with the virtual completion of the first post-war development programme. Much of the new plant was in full use for the greater part of last year, initial operating difficulties were overcome, and the additional available capacity, of course, made a notable contribution to the year's production of 11,200,000 tons of pig iron and 17,600,000 tons of steel. To the information contained in the Federation's report, there could fittingly be added a comment that "progress continues to be made." The Iron and Steel Board has now taken on the responsibility for providing statistics about iron and steel output, and a survey which it has recently prepared of the industry's activities in the first three months of the current year is distinctly encouraging. Steelmakers are no longer anxious about raw material supplies; pig iron output is at an increasingly high level with the commissioning of new and rebuilt blast furnaces, and, for the first time for many months, scrap supplies are described by the Board as "plentiful." Thus, with extended capacity and more adequate supplies of raw materials, it already seems certain that a steel production of 18,500,000 tons will be achieved this year if, as the Iron and Steel Board remarks, "this output is required."

Additional iron and steel-making capacity and plentiful supplies of raw materials are, however, not the only factors contributing to the industry's present rate of progress. The Federation's report fittingly draws attention to the fact that last year's expansion of steel production was accompanied by a further increase in productivity: the index of output per head in steel melting and rolling went up by no less than 4 per cent. The increasing efficiency which is apparent in the British iron and steel industry is a matter of no small significance. It is one which has undoubtedly helped to offset the rising prices which the industry has had to meet. One result, so far as last year was concerned, was that the industry's cost structure remained comparatively stable. Another result, and an important one in these days of greater competition, is that British iron and steel prices continue to be among the lowest in the world. The iron and steel industry's first post-war development plan was designed, of course, to improve technical efficiency as well as to provide more capacity. The measure of success attained may be gauged by the fact that, between 1946 and 1953, the average annual pig iron output per blast furnace increased from 92,600 tons to 126,000 tons and the average steel production per open hearth furnace from 36,800 tons to 52,600 tons. Now, the industry is busy on its second development plan, designed to provide for an annual production of 15,000,000 tons of pig-iron and 20,500,000 tons of steel by 1957 or 1958. The industry realises that, in the years ahead, the pattern of steel production will need to be guided more than ever by the changing requirements of consumers. It realises, too, that close attention will have to continue to be given to the problems of competition from other materials and the evolution of new uses for steel. Present industrial trends indicate no lessening of the demand for steel, but they do underline the necessity for continuing technical development. The British iron and steel industry's post-war production record and planning show how fully alive to that necessity the industry is.

TWO NEW BRITISH AIRCRAFT CARRIERS

Details were recently released of two new British light fleet carriers, which are about to join the active fleets to replace smaller and slower carriers earmarked for the Training Squadron. The two vessels—the "Centaur" and "Albion"—have been a long time building (both were laid down during the war) but the delay has been well worth while. During the intervening years British inventive genius has produced the angled deck, the steam catapult, improved arrester gear and other innovations which have made it possible to operate modern high-speed jet aircraft from fast, relatively small carriers. Even in these days of high prices, the "Centaur" has cost only just under £10,500,000 to complete, and it is thus well within our financial resources to build more of these ships, while at the same time perfecting our fighter aircraft and radar defences. Four other carriers laid down during the war are now being completed, but unless more are laid down without delay we shall have only seven carriers in all capable of operating modern aircraft. Much the same considerations apply to our strength in cruisers, which are essential both to act as escorts for the carriers and for the defence of the many focal areas of trade—the latter largely a British commitment. With the transfer of the "Nigeria" to the Indian Navy we have only twenty-three of these vessels—all completed or laid down during the war—five of which are approaching their age limit of twenty years. The United States is already converting some of her existing cruisers for firing guided missiles, and as it has now been decided to arm the "Defence," "Tiger" and "Blake" each with four 6in guns—leaving ample deck space for an additional armament of guided missiles—there should be no further delay in completing these three

powerful cruisers which have been laid up, incomplete, for so many years.

The four "Centaur" class carriers now being completed were originally designed for a standard displacement of 18,300 tons, but with all the additions and improvements they must now be well over 20,000 tons. They have not quite such good sea-keeping qualities as the very much larger "Eagle" and "Ark Royal" and they can carry only a much reduced number of aircraft. But they are in no way inferior in any operational role and are able to operate all types of modern naval aircraft. Both the "Centaur" and "Albion" have an extreme length of 737ft, an extreme breadth of 120ft 6in and an armament of eleven multiple and single-barrelled Bofors gun mountings controlled by modern close-range director systems. There are eighty officers and 950 ratings in the complement, as well as up to sixty officers and 300 air crew personnel, depending on the number and type of aircraft embarked. The generating plant consists of four steam-driven and four diesel-driven electrical generators, each of 400kW capacity, feeding a 220V d.c. water-tight ring main system, with a central large switchboard and four smaller switchboards for emergency use, the latter each controlling supplies to a quarter of the ship. Both ships are equipped with a comprehensive system of flight deck lighting to provide for night landing. Electric welding has been extensively used in the hull construction.

The hydrogen bomb, Mr. Attlee remarked recently, has brought us to a culminating point in the development of warfare. He might have added a plea that this country should now in consequence abandon a defence policy based on a lesser evil, the atomic bomb—a missile which is limited in its destructive effects to a large extent by having a critical size. But no country—not even the United States or Russia, vast though they are in area—could hope to continue a civilised life for long if subjected to many attacks from the hydrogen bomb. We have already stressed in these columns a practical and logical solution to this difficult problem. The Western Nations, while retaining the power to retaliate in kind and in greater measure, should reach an agreement with the Russians not to be the first to use explosives—necessarily including all radioactive material—which will exterminate both themselves and their enemies. Indeed, we consider the Prime Minister—who is probably the only man capable of doing so—should work also for a less controversial agreement with our United States friends. For Britain would be fully justified in leaving to the United States the very heavy expense of manufacturing missiles which may never be used, while we in turn bear a much greater share of the cost of what are called conventional forces—aircraft carriers, cruisers and fighter aircraft. What, indeed, could be better than a defence policy based on complete co-operation with the United States—a policy based on British and American sea power and on the ability of the United States to retaliate at once should an enemy start using radioactive material? While the United States retained her role of leader of the free world (in her position of the final "policeman"), this country would again be able to rebuild her sea power—at least on a basis of equality with the United States—and so regain her influence and prestige in world affairs. War is but a continuation of policy and it makes no sense to continue a policy which results in the annihilation of both belligerents. But until there is a change in human nature the resort to force may always be necessary as an alternative to abandoning a vital interest. And for Britain defeat is inevitable unless the sea routes between these islands, the Dominions and our allies remain open.

Literature

Report on the Atom. By GORDON DEAN. London: Eyre and Spottiswoode (Publishers), Ltd., 15, Bedford Street, W.C.2. Price 16s.

THIS book could hardly be other than important and authoritative, for its author, Mr. Gordon Dean, held the important position of Chairman of the United States Atomic Energy Commission during the years 1950–53, when so impressive an effort was made in that country to initiate plans for the efficient development of nuclear energy for civil power production. Mr. Dean does not claim that his book is a technical treatise nor in any way official pronouncement, but it is—to borrow his own words—an attempt to describe in straightforward and simple terms the major segments of the U.S. atomic energy programme which must be understood by Government officials, leaders in industry, and persons in all countries and in all walks of life "if we are to survive and handle ourselves wisely in the atomic age." He gives June, 1942, as the critical date when President Roosevelt, on the advice of Dr. Vanevar Bush, Vice-President Wallace, Secretary Stimson, General Marshall, and Dr. Conant, authorised the "magnificent gamble," costing nearly two billion dollars, which within three years enabled an atomic weapon to be used at Hiroshima and led to the result that within a week there followed the formal surrender of Japan.

With the coming of peace the eyes of the world naturally turned towards the possible use of nuclear energy for civil purposes and in the Acheson-Lilienthal report of March, 1946, a plan was put forward aiming at the international control of atomic energy; this, although generally endorsed by a United Nations Commission, was rejected by the U.S.S.R., chiefly no doubt on account of that Government's reluctance to agree to any form of international inspection which would suffice to ensure that civil stocks of fissile materials could not be surreptitiously diverted to military ends. This endeavour therefore remains in abeyance, but during the last few years some remarkable research work in America has shown how, in the meantime, nuclear energy can be made use of in field artillery, with the sure result of greatly increasing its fire power, and so largely removing the danger of aggression by any Power depending upon its sheer mass of man-power. (Facing page 97 is a photograph of an atomic artillery shell exploding.) Mr. Dean calls the past decade a "fluid period, an inventive period and a period of great haste, . . a time when people have concentrated, perhaps too narrowly, upon those projects with the greatest promise of immediate practical utilisation in the programme to acquire ore, produce fissionable material, and manufacture weapons." But in defence of this attitude he claims that it did much, as it still does, to prevent another world war.

The book has a valuable summary of the score or so of nuclear reactors already built in America, beginning with the famous original plant in the Chicago University Stadium (much resented by the displaced undergraduates, if rumour is to be credited), and including, of course, the power-producing prototypes of the last few years. An account is given also of the study groups set up by the U.S. Government; they consisted of several complementary pairs of industrial firms which had as their purpose a scrutiny of the most promising ways in which mechanical power might be produced from this new source of energy at a reasonably economical rate, in at least those parts of the world not already richly endowed with the older sources of power. In some of these studies it was proposed that the reactors should also produce plutonium for sale to the Government for military use; but the ideal aim cannot well be other than a single-purpose reactor, since the demand for plutonium for military purposes is hardly likely to provide a market of much stability.

If uranium and thorium are to be regarded as effective alternative fuels to those we now have, it is necessary to assess how long the known supplies of them could be expected to last. It is difficult to make any reliable forecast at this early stage of the search for source materials, but the U.S.A.E.C. lately caused a rough survey to be made and, calling the world rate of consuming thermal energy expected to prevail, on present trends, up to the year A.D. 2000 "one unit" a year, the amount of uranium and thorium available would probably amount to some 1700 of such units—in marked contrast with a total of less than 100 units for coal, gas and oil, added together. This is encouraging, as it holds promise that there should be ample time to discover for still later use some means of drawing on the abundant energy continually radiated from the sun, so little of which is at present recovered at all.

Another especially interesting chapter of the book describes not only the many uses of radioactive isotopes specially prepared for service in medicine, in biological research and, more recently, in various industrial applications, but it foreshadows the possible inclusion of some at least of the mass of fission products from nuclear reactors hitherto treated as waste material. Among the suggested uses are the making of permanently fluorescent light tubes and novel means of manufacturing certain chemicals—but this field of work still awaits exploration.

The author has naturally much to say about the administrative problems which grew out of the requirements of the Atomic Energy Act of 1946 (the McMahon Act). This measure placed atomic energy under civilian control, but provided that there should be adequate opportunity for the War Department to participate in those developments having a military application. This interpretation of the Act is thus endorsed by General Bradley: "The Defence Budget is not in reality a military budget; it is a civilian budget. Civilians are in charge." Mr. Dean appears to have found this system to work well, but he does urge that it needs to be supported by much closer co-operation than now exists between the Joint Chiefs of Staff Committee and the Atomic Energy Commission. This has its lesson for Britain, since it raises a point which needs to be closely watched whilst our own new arrangements for the switch of control from the Ministry of Supply to the newly created authority are being framed.

Mr. Dean has certainly written a very useful book which, without being chiefly historical or really technical, gives nevertheless a vivid picture of the administration of

current developments in nuclear engineering in the United States. As it happens, its publication is almost simultaneous with that of our own Government's modest little volume, *Britain's Atomic Factories*, which was noticed in this journal on January 22nd last.

Heavy Water Atomic Reactor at Harwell

WORK has been started on the site of a new reactor at Harwell. It will be the fourth pile to be built at that establishment and the first in Great Britain using heavy water as a moderator. It may be recalled that for the last six years Harwell has had available two piles, BEPO and GLEEP, which have been used for research in a variety of subjects. In particular they have been used for work carried out in connection with the design of the plutonium producing piles now in operation at Windscale and the newer nuclear energy electricity generating station now under construction at Calder Hall. However, the more advanced designs of power pile to which Harwell is now giving detailed consideration are likely to operate at a much higher intensity than has been the case previously, and this should lead eventually to a reduction of capital costs and lower overall costs of reactor operation.

Accordingly, it has been decided to build at Harwell, in addition to the Zero Energy Fast Fission reactor (which has now been operating for some two months) a small research reactor operating at a very high intensity to facilitate the necessary experimental studies. The new pile will also make it possible to produce certain radioactive isotopes such as cobalt-60 which cannot be made with sufficient specific activity in BEPO. Until now BEPO and the Windscale piles have been the main source of the radioactive isotopes in which A.E.R.E. has a large international business.

The use of heavy water as a moderator enables the required facilities to be obtained at a lower capital cost than would be possible with a graphite moderated system. For fuel the reactor will use highly enriched uranium which will be supplied from the diffusion plant operated by the Atomic Energy Industrial Group at Capenhurst.

The general design of the new pile is being undertaken by the Atomic Energy Research Establishment, whilst detailed design and provision of reactor components will be a responsibility of Head Wrightson Processes, Ltd. The Ministry of Works are undertaking civil and general mechanical work in connection with site services, building and installation.

Books Received

Densening and Chilling in Foundry Work. By E. Longden. London : Charles Griffin and Co., Ltd., 42, Drury Lane, W.C.2. Price 28s.

Form in Engineering Design. By J. Beresford Evans. London : Oxford University Press, Amen House, Warwick Square, E.C.4. Price 10s. 6d.

Discontinuous Automatic Control. By Irmgard Flügge-Lotz. Princeton University Press. London : Oxford University Press, Amen House, Warwick Square, E.C.4. Price 32s. 6d.

The Manufacture and Properties of Steel Wire. Second edition, translated from the German. By A. Pomp. London : The Wire Industry, Ltd., 33, Furnival Street, E.C.4. Price 84s.

The Crystalline State. Vol. III : *The Determination of Crystal Structures.* By H. Lipson and W. Cochran. London : G. Bell and Sons, Ltd., York House, Portugal Street, W.C.2. Price 50s.

Applied Thermodynamics. Third edition. By the late W. Robinson, revised by J. M. Dickson. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 40s.

Solution of Problems in Engineering Drawing and Projective Geometry. By K. L. Jackson. London : Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 10s.

Business, Legal, and Ethical Phases of Engineering. Second edition. By D. T. Canfield and J. H. Bowman. London : McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 48s.

Institution of Naval Architects

ANNUAL SPRING MEETING

No. IV—(*Continued from page 647, April 30th*)

THE spring meeting was continued in the morning of Friday, April 9th, under the chairmanship of Sir Charles Lillicrap, with the reading of :—

SHIP TRIAL PERFORMANCE AND THE MODEL PREDICTION

By DR. J. F. ALLAN and MR. H. J. S. CANHAM

SUMMARY

The paper gives the results of ship-model comparison studies made jointly by the British Shipbuilding Research Association and the National Physical Laboratory. Ship trial procedure is outlined and the limits of liability to error in taking the various measurements is stated. The resistance and propulsive experiments were carried out with wax models using the normal N.P.L. method and the results are analysed using the Standard Froude friction data and also using the Schoenherr friction formulation. Tables give the leading particulars of the vessels on trial and a comparison of ship and model results, while another table summarises these results at the design speeds. Certain points arising from the results are noted and the reasons for variations deduced, while a tabular statement shows a comparison of effective horsepower by Dr. Hughes's method and that derived from ship power and thrust.

DISCUSSION

Professor L. C. Burrill : The results, when first looked at, might lead us to think that our basis for powering ships is unstable and unsound. On closer examination it is to be realised that here we have the comparison between self-propelled model tests and the ship and not a comparison with what the naval architect decided was to be the power for the trial or what the propeller designer decided were to be the propeller revolutions for the ship. I think that is an extension of this investigation which might well be carried out.

These enquiries represent a welcome development in the scheme embracing tanks, naval architects and shipbuilders. There was a time when shipbuilders, naval architects and engineers had to use their own judgment and to put their own correction factors on to the figures they received from the tank. But this interest taken by the B.S.R.A. and the tank gives them something much more solid to go on. Unfortunately, there has been an interim period when the shipbuilders have been inclined still to use their own margin, forgetting that the tanks are considering this matter.

From experience of analysing both trial and voyage data I have concluded, first, that the results of single tests with self-propelled models are not always to be trusted as a guide to design. I recognise the value of self-propelled model tests as an indication of the hull efficiency element, but I prefer the method of deciding the final performance for the ship by referring to standard series data from large-scale propellers. Secondly, ship trial figures are not always reliable, but they show where the fault is. In my opinion the weather effect on trials is very much more than is usually expected.

It would be well to extend this investigation by adding a comparison between the effective horsepower predicted from the model and the effective horsepower measured which appeared on either an Ayre or a Taylor standard basis. On the propeller side I recommend the authors to compare not only their prediction from the model, but also the power and revolutions intended by the shipbuilders on trial and in service, with what was actually obtained. I cannot believe that the revolutions are 5 per cent different. I think the investigation should include an analysis of the wake factors obtained from the ship data. That will give a great lead to the shipbuilders and designers in deciding what is the difference between the conditions under which the model propeller goes down the tank behind the model and the condition in the full-scale ship. I do not believe that the effect of welding is as much as 15 per cent, but would have thought it was about 8 per cent.

Mr. Ewan H. Smith : The difficulty I have in considering the implications of this paper is that so many factors have to be taken into account, and after that consideration the validity of the whole of the conclusions is based entirely on one single factor, which is the measurement of the power developed by the machinery.

I can identify quite a lot of the ships in Table I [of the paper], and I would refer particularly to the ship S.19. The Admiralty constant of 494 for that ship, in Table II, is based on torsion meter readings which, by a number of cross checks, is at least 10 per cent less than the true horsepower which we believe was delivered by the engine. In that particular case the power comparison shows that the model experiments were predicting power 15–16 per cent above the actual ship performance, if you accept the torsion meter readings for the ship. If you accept the horsepower which we considered was being developed by the machinery, that particular example alters the whole perspective of this sort of comparison.

Torsion meters of the type used in the B.S.R.A. trials have been checked satisfactorily against dynamometer readings on the test bed, but the dynamic conditions are very different from those which occur in the line shafting of oil engine machinery fitted in the after end of a ship. I cannot help feeling that very much of the value of the paper is invalidated by the reliance which has been placed on the Siemens-Ford torsion meter as a scientific instrument for the measurement of output. It is an invaluable commercial instrument, but I do not think it is accurate enough for such important conclusions as these.

Another potential source of error is the assumption that the shaft losses amount to 3 per cent. Has any attempt been made to deduce the amount of shaft friction where progressive trials have been carried out, by plotting the torque against the square of the revolutions and extrapolating to zero revolutions ? This will at least have some relative value in comparing the results of sister ships which are included in these comparisons. Alternatively a static friction test could be carried out in dry dock, with the shafting uncoupled.

It is said that allowance has been made for wind resistance. How is this correction applied for a beam wind, such as applies so often at Skelmorlie, where more than 25 per cent of the trials under review were carried out ? The effect of a beam wind can be very considerable on the performance of a ship.

The present N.P.L. practice when predicting performance from model experiments has no significance unless the basis from which the correction has to be made is explained. This basis has hitherto included a standard allowance of 10 per cent for appendages, &c.,

which for the all-welded ship has then to be again taken away.

The power comparisons in Table II are stated to be based on Froude naked e.h.p.'s without any allowances. Referring again to that table, it would be interesting to have the views of a statistician on the validity of taking the arithmetical average of the power comparison for each group as being a correct conclusion to be drawn from the results for that particular class of shell finish. On fuller consideration of Table II I wondered if the method on which the power comparison has been carried out is of the value which this paper might imply. It is rather unfortunate that we have become so embedded in this use of power in the consideration of ship propulsion and resistance. We have to get back more to the aeronautical basis of considering torque and thrust.

Commander L. A. Rupp (U.S. Navy) : The collection of accurate ship trial data is a difficult, and sometimes a frustrating experience, for random and systematic variables creep in which are not susceptible of direct analysis. Often some of the data on which these variables could be evaluated is not obtainable ; therefore we adopt the statistical approach, using data from a number of trials to cancel out the random errors and hoping thereby to separate out the constant and systematic variables. There may be some danger in this approach if there are too many unknown systematic variables.

For example, in Figs. 1, 2 and 3 the authors endeavour to separate out the frictional resistance effects associated with hull structure, and conclude that the reduction in power for the total change from all-riveted to all-welded construction is probably about 15 per cent. N.P.L. practice in predicting performance increases this figure to 20 per cent. This deduced difference may be too great in view of the lack of correlative data for the actual paint roughness of the vessels concerned. For instance, the all-riveted ship No. 56 required 8·3 per cent less power than predicted, even though it is one of the ships on which trials were conducted after more than twenty days out of dock. Several freshly-painted all-welded ships had from 3 to 5 per cent greater resistance compared to the model prediction. This discrepancy is much greater than the acknowledged maximum liability to error in the trial data. Therefore, a statistical analysis of resistance, based only on structural roughness of the hull as a variable, may be misleading.

Under " Ship Trial Factors " the authors state that a torsional modulus of $11{\cdot}95 \times 10^6$ lb per square inch was used for all the trials. Compared with experience from shaft calibrations in the United States, this figure agrees quite well with the average modulus values for carbon steel shafts. However, additions of alloying elements may introduce appreciable variations. Nickel additions depress the modulus, while some other normal alloying elements increase it.

Concerning bearing losses, I ask how the " standard " reduction of 3 per cent to be taken from the measured shaft horsepower to obtain the drawbar horsepower at the propeller was derived. About twenty years ago careful tests were carried out to determine bearing losses on a destroyer in the United States and at the design revolutions per minute the total power losses from three outboard water-lubricated lingum-vitæ bearings, three oil-lubricated steady bearings, and a stern tube stuffing-box amounted to only one-quarter of 1 per cent of the full power. Even assuming the losses at 1 per cent for a single-screw merchant ship, the ship model resistance correlation plots in Fig. 1 [of the paper] would be raised 2 per cent and in Fig. 4 nearly all the Class A trial results would lie above the Schoenherr line. Also this change would bring the average thrust and power results more nearly in line with each other.

Variations in paint applications or other built-in surface roughnesses can overshadow all the gains from extensive design studies and model testing efforts and the real effort must be to minimise the shaft horsepower, integrated over the full period of time between routine dockings.

I think the hull frictional surface roughness effects will be brought out by wake analysis ; and at times they have shown ship wakes considerably greater than model wakes. This may account for some of the discrepancies mentioned in model propeller revolutions-per-minute prediction. Development of methods of providing better control of paint roughness, coupled with optimum anti-fouling properties, offer the greatest scope for improvement in ship performance.

Mr. J. L. Bessant : The accurate prediction of ship performance from the results of model experiments has for many years been a primary objective of the Admiralty Experiment Works, Haslar. A description of the Admiralty method of analysis was given by Payne in a paper read before this Institution in 1934, and there is a further reference, dealing particularly with the cavitation aspect, in a paper by Dr. Gawn before the North East Coast Institution in 1949. The method differs in a number of respects from that employed by the authors. In particular it is not regarded as satisfactory to rely on propeller efficiencies determined from the model ; instead, these are determined from a large-scale methodical series of propeller tests. It is possible that both the scatter and the quantitative deductions may be influenced by propeller scale effect.

It is obvious that the ranges of interest for merchant ships and warships, while parallel, seldom overlap. Warships are generally characterised by finer forms, higher speeds and multiple screws, so that, compared with merchant ships, skin friction and hull roughness are a little less important, hull efficiency elements are smaller and the effects of shallow water and cavitation relatively more important. There is considerable common ground in analysis and there may be something to learn by applying Haslar methods of analysis to the ship trial and model experiment data available. and this work has commenced, in the hope that some light may be shed on the wide scatter shown in these results.

In connection with this scatter, it is clear that the reasons must lie largely at the ship end and no change of technique of model experiment or trial analysis is likely to appreciably reduce it. The restricted scope and lack of precision of trial records is partly responsible in spite of the effective control instituted by B.S.R.A. in their code of procedure for trials. No one could be expected to predict the trial results within plus or minus 5 per cent in power and until substantial improvement is made in allowing for trial conditions and hull and propeller conditions it is unlikely that the ship trial can give guidance in the matter of what particular formulation we should use, if we are dissatisfied with Froude, to calculate the ship skin friction.

The authors have made an effort to bridge the scatter by a series of steps graded to the degree of structural finish of the shell ; and there is good evidence to show that structural finish is an important parameter. It is of interest to note that by comparing the Class A trials as a whole, which were on the average seven days out of dock, with the Class B trials, which were sixty-one days out of dock, it can be concluded that the effective horsepower is increased by one-fifth per cent per day out of dock.

Professor E. V. Telfer : With regard to Dr. Allan's preference for the double-run method of conducting a trial, I fully agree with him, and I would go further and recommend, as the result of very much analysis work, that there should be a single run at different revolutions right up in the scale, culminating in the final contract speed at the double or single run, as the owners may prefer. That gives much information and the need for such information is clearly endorsed by the paper.

The point has been brought out by speakers as to the value of 3 per cent as standard reduction for the shaft transmission efficiency. I strongly recommend that work of this nature should always be preceded by a consideration of the generalised power diagram for each ship. It is easily the best method of sorting out all the distracting errors that can arise and confuse the investigator.

Two years ago, in Italy, I gave a paper on ship-model correlation and made a statement that over-estimates of the order of 30 per cent in the power necessary for ships are not unknown, and was told that I had hopelessly over-stated the position. If you turn to Fig. 1 in the present paper—remembering that at the Teddington tank they do not start from zero on that diagram, but from zero plus 10—and fix your mind on the 10 per cent plus line at the top, and then drop to the great multiplicity of data at the bottom and down to minus 20, straight away you are in the order of 30 per cent. So that I am not sure that I was exaggerating. On the question of scale effect, in Table III the authors consider the possible merits of the Hughes proposal. Taking the two right-hand columns, where you have the prediction from the Hughes line for the first tanker, if you use power measurements the percentage of ship effective horsepower above the Hughes line is 18·6, and if you use thrust measurements the percentage is 32·5. It is perhaps unfair to Dr. Hughes to make such a comparison, in view of the scale effect in thrust deduction, and in single-screw ships the thrust deduction becomes smaller as the model size increases. So that the 32·5 per cent is an over-estimate.

(*To be continued*)

Book of Reference

British Diesel Engine Catalogue. Third edition. The British Internal Combustion Engine Manufacturers' Association. London : Temple Press, Ltd., Bowling Green Lane, E.C.1. Price 52s. 6d.—The previous edition of the *British Diesel Engine Catalogue* was published in 1950, and this, the third, edition, brings that information up to date and indicates the progress made in the industry since 1950. A foreword, given in French, Spanish and Portuguese, reviews the current situation and general developments with regard to the various engines, and this is followed by brief explanatory notes and diagrams concerning oil engine working principles, engine and fuel standards and other matters of technical interest. There is an index giving the various makes of engines divided into classes and also a lightning index in which the engines are listed in ascending orders of powers and grouped both according to design and to application, such as industrial duties, railway traction purposes, marine propulsion and marine auxiliary services. The remainder of the catalogue contains data of the various makes of engines, set out in alphabetical order, and the tabular statements of particulars of the engines of the various manufacturers are all of standard form to enable comparisons to be made easily and quickly. The catalogue contains detailed information covering 2267 engines manufactured by some thirty-eight builders, and ranging in power from 1·5 b.h.p. to 10,800 b.h.p. Engines capable of working on gas or as dual-fuel units are also included.

Portslade Gasworks

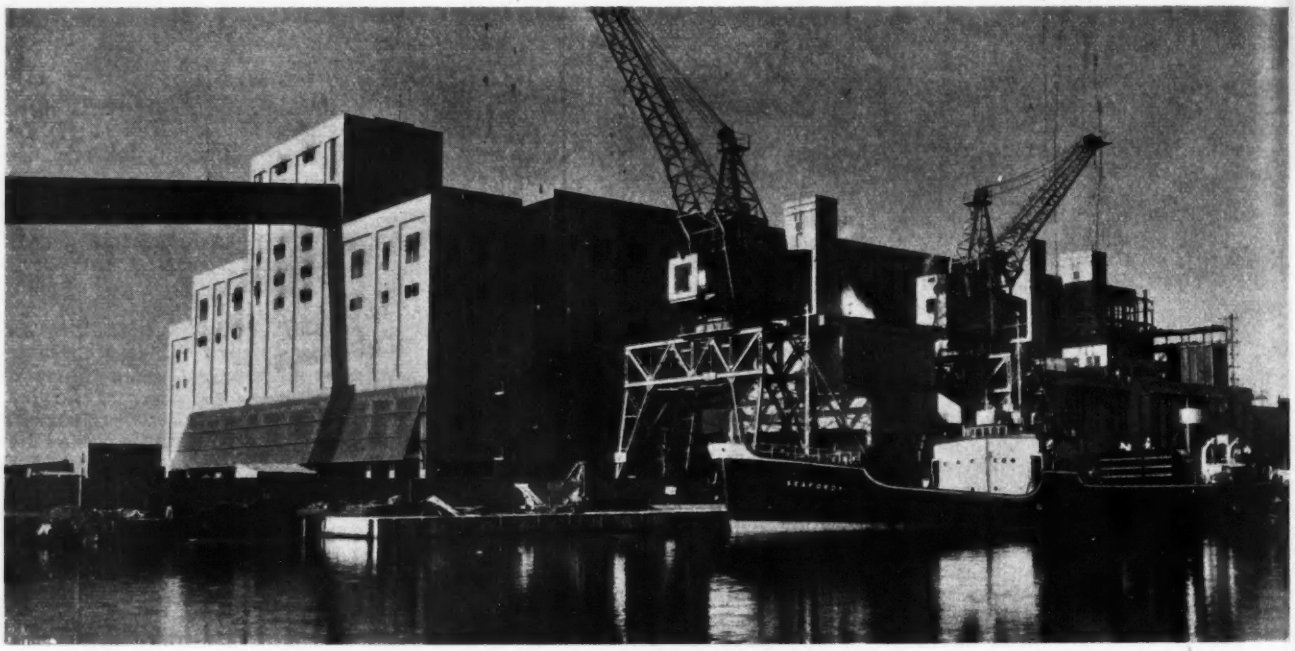
The new vertical retort plant at the Portslade works of the South Eastern Gas Board was officially inaugurated on Monday last by the Duke of Norfolk. These new works have cost some £3,000,000 and will soon have a daily output of about 17,500,000 cubic feet of gas. They form a major part of an extensive re-organisation scheme and will eventually provide gas for a large area in Sussex, when a number of smaller works will be closed.

TO meet the growing demands for gas in a large area of Sussex the directors of the former Brighton, Hove and Worthing Gas Company, in 1946, decided to carry out a complete reconstruction of the Portslade works. This project envisaged the installation of new carbonising plant and new handling arrangements for coal and coke. It was put in hand early in 1948, when tenders were accepted from the Woodall-Duckham Company, Ltd., for carbonising plant, with a capacity for 15,000,000 cubic feet a day, together with coal and coke handling plants and extension of the existing wharf in Shoreham Harbour. Construction of the retorts was to be carried out in three sections, each with a daily capacity of 5,000,000 cubic feet, and provision was to be made for a fourth section of similar capacity. The handling plant scheme provided for the installation of additional coal conveyors and an extension of the coke plant when the fourth section of the carbonising plant was installed. These reconstruction plans for the Portslade works were well in hand when, on nationalisation in 1949, the company was taken over by the South Eastern Area Gas Board.

Two carbonising sections of the new plant had been completed and the third was in an advanced state of completion when a new vertical retort plant was officially inaugurated on Monday last by the Duke of Norfolk. This new plant has cost some £3,000,000 and with it the South Eastern Gas Board plans to take full advantage of the increased capacity. In a works the size of Portslade, where supplies of coal can be taken directly from sea-going ships, gas can be manufactured far more cheaply than in the smaller gasworks which serve the surrounding countryside. As part of a comprehensive scheme to replace these smaller plants mains are already being laid to supply gas to Newhaven and Seaford, where the existing works are to be shut down at the end of this year. As more gas becomes available from Portslade mains will be laid to supply gas to other parts of Sussex, including Littlehampton, Arundel, Petworth, Billingshurst, Haywards Heath, Lewes, Uckfield, &c. When this scheme of integration is complete it is estimated that the production of the Portslade works from the vertical retorts and carburetted water gas plant will be 25,000,000 cubic feet a day.

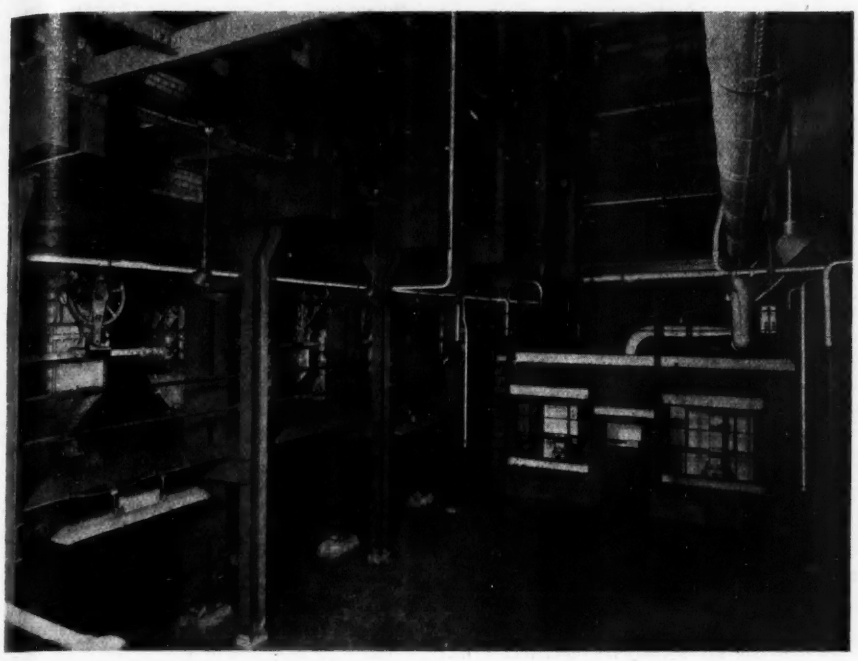
The main parts of the new plant are enclosed in a steel-framed building, attractively panelled with "golden faced" Southwater bricks. This building can be seen in one of the illustrations on this page. The nature of the subsoil and the proximity of the works to the sea made it necessary to build the installation on reinforced concrete piles, some of which were driven to a depth of up to 70ft below ground level. Water was found at about 7ft below the surface of the site and this added considerably to the difficulties of constructing a large reinforced concrete pit 16ft deep which accommodates the coal and coke elevating plant.

To provide adequate facilities for the vessels bringing coal to the works the old wharf has had an extension 809ft long added to its eastern end, and the berth was dredged to a depth of 19ft. This will enable colliers of 2000 tons capacity to serve the works as soon as the entrance to Shoreham Harbour has been enlarged to admit such vessels. Two travelling electric cranes, each with a maximum capacity of 240 tons an hour, unload coal from colliers at the new wharf and discharge it into a central receiving hopper.



New Retort House and Coal Unloading Plant at Portslade

Coal Storage Hoppers Above Retorts and Shuttle Band Conveyor



View Between Benches Showing Coke Extractors and Side of Retort Bench

Each of these level luffing cranes is designed to lift a total load, including the grab, of 8½ tons at a maximum radius of 70ft. The dumping grabs used each have a capacity of 130 to 165 cubic feet or about 3½ tons. When handling run-of-mine coal each crane has a capacity of 180 tons an hour, and this capacity is increased to 240 tons an hour when handling graded coal.

The cranes deposit the coal into a central 200-ton reinforced concrete receiving hopper, whence it is fed by vibratory feeders on to two belt conveyors. These conveyors transfer the coal at a rate of up to 250 tons an hour to a system of gravity bucket conveyors which take it to the storage hoppers above the retort settings shown in one of the illustrations on page 682.

Alternatively the conveyors transfer the coal to another system of belt conveyors which deposit it in an open storage yard at the far side of the plant. If required, coal can be transported on the system to the storage hoppers and the yard at the same time. The coal is automatically weighed and recorded during transfer and an automatic device is installed for collecting samples from the feed to the overhead hoppers at predetermined intervals. The coal storage yard is served by a drag scraper capable of reclaiming up to 250 tons an hour, and the yard is arranged to accommodate about 20,000 tons of coal. If necessary the incoming coal to the overhead hoppers can be passed through a set of roll breakers. These hoppers over the retorts have a capacity of about 500 tons for each bench and provide storage sufficient for fifty hours' consumption.

Each of the three sections of the new carbonising plant consists of fifty-six continuous vertical retorts arranged in two parallel benches of twenty-eight retorts. Each retort is about 25ft long with a major axis of 82in and a minor axis tapering continuously from 10in to 20in. The retorts are fitted with standard Woodall-Duckham coke extractors, water sealed dischargers, and liquor-sprayed gas-offtakes. The extractors can be seen in the photograph reproduced on this page. Independent heating control is provided to each retort which has its own producer gas, secondary air and waste gas flue dampers, a lambent heating system being employed. A single damper controls the producer gas on each side of a retort, but the secondary air can be admitted at up to four levels. This secondary air is preheated by circulating round the seating castings and supporting steelwork before it is admitted to the setting, where it is further heated in passing the heating flues.

Each retort bench is heated by gas generated in mechanical producers placed at ground level on the outer side of the bench. Ten of these producers have been supplied by Humphreys and Glasgow, Ltd., and four are used as standbys whilst the others are in use.

Each bench is provided with its own chimney, crude gas mains and governor, coke extractor driving gear and waste heat boiler plant. The ten waste heat boilers for the three sections have a working steam pressure of 150 lb per square inch and each is rated to produce 11,000 lb of steam an hour. Some of these boilers can be seen on one side of the producer charging platform in the illustration below. Provision is made for augmenting, if necessary, the waste gases entering the boilers by the combustion of producer gas. Steam admitted to the base of every retort serves the dual purpose of producing blue water gas by reaction with the hot coke, and of cooling the coke in the base of the retort. The crude gas from each bench passes into collecting mains, through a governor which regulates the gas pressure within the retorts, and thence by way of two 36in steel overhead mains to the exhausters and purification plant which formerly served the horizontal retort houses.

Ammoniacal liquor is circulated to the sprays on the gas off-takes, collecting mains and crude gas mains, by centrifugal motor-driven pumps. Each pump is capable of dealing with 4500 gallons of liquor an hour, i.e. the requirement of one retort bench, one additional pump being provided as a standby for each two benches. Each bench has its own tar and liquor circulating and separating tank.

The atmosphere in the retort house is comparatively dust free owing to the employment of mechanical producers and dust extraction plant which assists in securing clean secondary air.

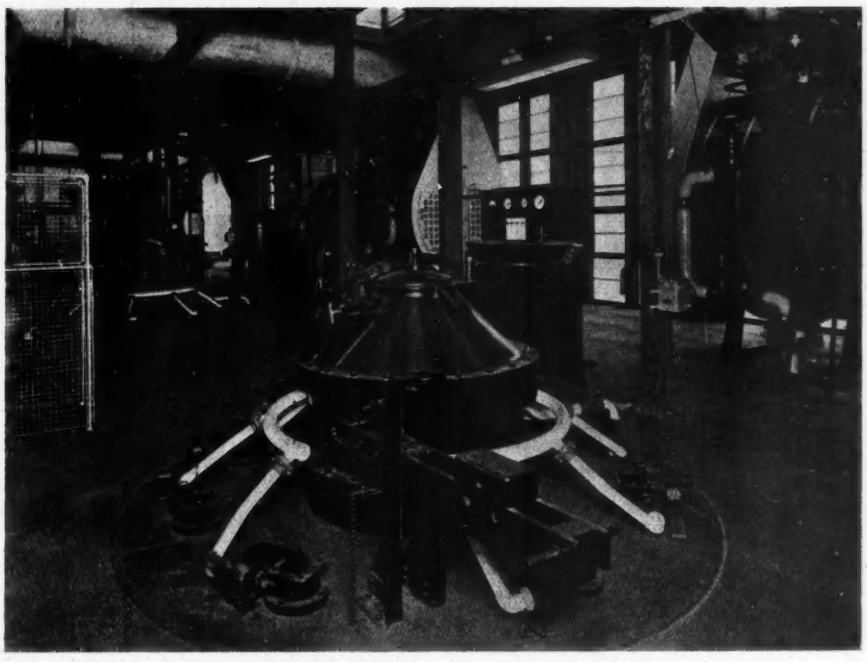
With the three sections of this plant in operation and carbonising Yorkshire coals, after allowing for the extraction of 2 gallons of benzole a ton of coal carbonised, the net daily output will be about 17,500,000 cubic feet of gas at a calorific value of 505 B.Th.U. per cubic foot. Each section will carbonise approximately 420 tons of coal a day.

The ten mechanical gas producers which provide the gas for heating the retorts each have an annular waste heat boiler which produces steam at 20 lb per square inch and evaporates about 1800 lb of water an hour. This low pressure steam, together with other exhaust steam, is used for steaming the retorts and for saturating the producer blast. Any excess steam is used for heating the boiler feed water.

A travelling chute beneath the retorts receives coke from the water-sealed dischargers and delivers it on to a belt conveyor. This conveyor delivers the coke into gravity bucket conveyors which elevate and discharge it on to a further belt conveying system, leading to a coke screening plant or to a storage yard. The four sets of equipment in the coke screening plant were supplied by Pegson, Ltd., and each comprises a scalping screen and primary and secondary grading screens. The coke is graded into four sizes and each set of equipment is designed to handle up to 50 tons an hour.

After screening the coke passes to steel-framed, brick-panelled bunkers with a total storage capacity of 1200 tons of coke and breeze. From the bunkers the coke may be delivered by chutes directly into road vehicles either in bulk or via bagging and weighing machines. In both cases the coke passes over breeze screens before being loaded.

Coke required for the mechanical producers, and for the retorts when starting up or after



Producer Charging Platform with Waste Heat Boilers at Rear

scurfing, is delivered from the coke storage bunkers in the screening house. Delivery is effected by belt conveyors which discharge on to the bottom strands of the coke gravity bucket conveyors. The coke thus elevated is discharged on to belt conveyors which distribute it either into the retort coke storage hoppers or into the producer coke storage hoppers.

Power for the plant is provided mainly by electricity but the waste heat boiler fans, the coke extractors and boiler feed pumps are steam driven, as also are a few standbys for vital units. Electric current is purchased from the British Electricity Authority whose Brighton "A" power station adjoins the gasworks. Current at 11,000V a.c. is received, via two main cables, at the Board's main substation situated in the works. From this substation new feeder cables lead to transformers in a substation in the vertical retort house where the voltage is reduced to 415V for use in the plant.

Flame Research Station at Ijmuiden

Some details are given of the research facilities in the new research station built for the Flame Radiation Joint Research Committee at Ijmuiden, Holland. The oil and gas-fired furnace is described and the necessity for almost full-scale research explained.

ON Wednesday, April 28th, we were invited by the Flame Radiation Joint Research Committee to attend the opening of its new research station at the Royal Netherlands Blast-Furnace and Steel Works at Ijmuiden. Work carried out by this international organisation, with its original facilities, has already been widely published.* Its future programme will be based on two specially designed furnaces in the new building—both being relatively full-size installations. One of these furnaces, that for oil and gas firing, has been running for about two months. The pulverised fuel furnace is not yet completed.

At the ceremony the future programme of the organisation was referred to by Professor O. H. Saunders, chairman of the British Committee. In his remarks he explained the unfortunate necessity of having to work with costly new full-size furnaces when investigating the phenomena of flame radiation. He stated that whilst the fundamental parameters controlling the physical processes were well known, being in effect the Reynolds numbers of the fuel and air streams, much less was known about the chemical parameters except that the time of residence of the burning fuel in the flame was very important. It was immediately obvious that a reduction in scale, even if accompanied by strict geometrical similarity of furnace and burner, necessitated an increase in velocity if the Reynolds numbers were to be held constant, and that this requirement conflicted when maintaining the time of residence constant. In other words, when passing from a larger to a smaller flame, it was not possible to satisfy the requirements for keeping the physical and chemical effects in the same balance.

Even if this were possible, he went on, there was still the difficulty that radiation obeyed an exponential law of variation with thickness of flame, which meant that the bigger the flame the relatively more important the contribution of radiation from the outer parts than from the inner parts. In the extreme case of a large, highly opaque flame, the radiation from the centre would be largely absorbed in the outer layers before it escaped. Unless, therefore, the index in the exponential law was constant and known, it was impossible to predict the radiation, or its variation with flame size. In its work the committee had deliberately chosen flames large enough for the results to be safely extrapolated to industrial conditions—at least it hoped so—but at the same time work was being done in Sweden and elsewhere on small flames. So far the results suggested a solution to the complicated problem of relating the performance of the two furnace sizes.

It was also very necessary to explore the effects of air preheating, which was one of the most difficult effects to predict theoretically, and the future programme included the installation of the necessary preheater as one of the most important items.

As to the usefulness of the data obtained on the Ijmuiden furnaces in other industries, Professor Saunders said that they were studying the flame rather than the furnace, including the methods of injection of the fuel and air. It was believed that in this broad sense the combustion conditions and hence the radiating properties of the flames were not greatly affected by the presence of the walls of the furnace, and that the results obtained with different kinds of flames, including different burners and air inlet systems, would, it was hoped, be of general application. There was one important exception, namely, the cold wall furnace in which it was believed that the walls may affect the rate of combustion. This type of furnace was mainly the concern of the boiler industry, and it was intended to give attention to this case.

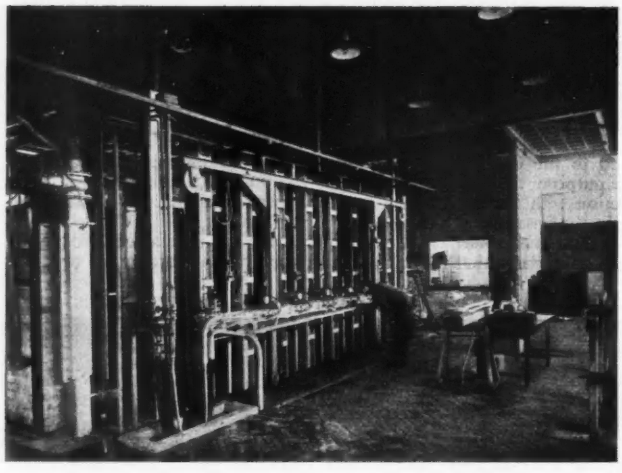
The completed furnace for oil and gas firing has an inner cross section of 2m by 2m and its length 6·3m. The construction of the side walls, through which the measurements must take place, had to be a compromise between what was required for thorough investigations (in effect, a wall consisting of holes and slits only), and what was considered to be necessary for a solid construction with adequate insulation. In view of the discontinuous operation of the furnace, and the frequent temperature level changes, it was considered unwise to make slots over the whole height of the furnace. Accordingly four slots in the later part of the flame have only a central slit, while holes are provided for the rest. The width of the slots and of the holes is 8cm, and in order to make the construction of the whole side wall a stable one, specially shaped bricks have been inserted.

Since the desired aim was to work at wall temperatures of 1600 deg. Cent., sillimanite was chosen as the refractory material. The complete wall is constructed of one brick (22cm) of sillimanite, a half-brick of porous sillimanite acting as a high-quality insulating brick, and a half-brick of ordinary insulating brick.

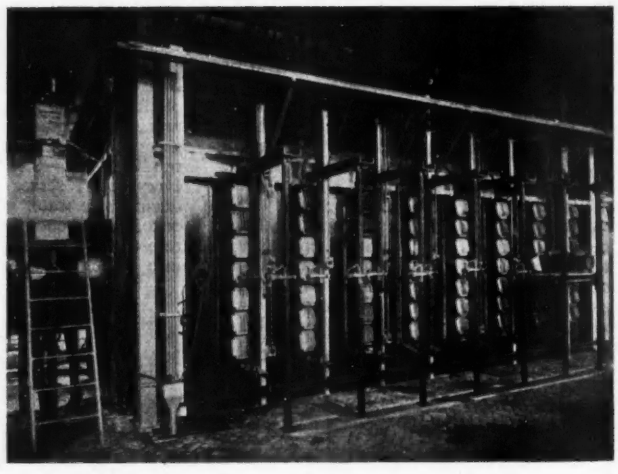
Roof and bottom are of the same composite character as the walls. The whole furnace, except the roof, is within a light steel casing and rests on a set of beams. It may thus be possible to measure the heat losses through the floor. The burner is in a receding entry, the air being delivered by means of wind boxes giving a fairly even distribution of the air in height.

The exit end of the furnace is constructed to provide a venturi-shaped waste gas tunnel with the idea of improving the mixing before the waste gas samples are taken for temperature and gas composition measurements; in addition this venturi may be used to measure the waste gas volume and provide a check on the waste gas analyses. A furnace pressure damper control is provided; this consists of two refractory plates sliding vertically in opposite directions.

Work of a different character will be done through each of the side walls, the east wall being used for radiation measurements only, the west wall being designed for the insertion in fixed and known positions of all the various kinds of probe. A horizontal beam has been designed on which all the radiation pyrometers can be mounted with their supplies for water, clean air and wiring. This beam, which is shown in our illustration, can be raised up and down by means of two long screwed spindles mechanically coupled. The water-cooled doors have been made to slide along a pair of water-cooled tubes, one on each side of a slot. This sliding door, of about twice the furnace height in length, is counterbalanced and thus easily moved up and down, by means of an interlocking pin on the horizontal beam. In this way the holes in the doors are always in line with the radiation pyrometers on the beam, and at the same



East Wall of Oil and Gas Fired Furnace Showing the Pyrometer Traversing Beam



Fixtures for Securing Probes on the West Wall

* See THE ENGINEER, June 20, 1952, page 822.

time reasonable airtightness has been secured.

On the west wall (also illustrated) fixed doors have been provided to cover the slots; these doors have eight square holes with flaps, which can be used for introducing water-cooled probes. On the outside of the furnace are a number of vertical pipes with sliding grips which can be used to fix in position probes or any other instruments. These arrangements enable a figure for inlet air ranging from 0 to 15 per cent according to furnace pressure setting, the greater part of this inlet air being produced by the openings in the sliding doors for the radiation pyrometers.

Supply and Control of Input Variables.—All input variables are under complete automatic control. Oil is preheated before being pumped to the furnace. Two pumps are provided: one for quantities above 50 kg.hr^{-1} and an adjustable diesel engine fuel pump for the small quantities used for carburetting gas flames. The larger quantities are measured by means of an orifice specially designed for viscous liquids and working on a recording controller.

Steam (after being superheated in a small gas-fired unit), compressed air, coke oven gas and oxygen, can be taken from the works mains, measured by orifices, and controlled to give a constant flow.

The combustion air is delivered by fans. Once the air preheater has been installed any air temperature up to 750 deg. Cent. can be supplied. Furnace pressure, although not an input variable in the strict sense, is measured and controlled by a hydraulic controller, operating on the two damper halves, which counterbalance each other. The measuring and controlling instruments for the input variables are mounted on one wall of the instrument cabin. The average load of the furnace will be roughly 250 kg of oil or 600 cubic metres coke oven gas per hour.

The foundations are completed of the furnace for pulverised fuel firing, which has been designed along the same lines as the oil and gas furnace, though having a ratio of length to cross section of about 7 : 1, as compared with 3·5 : 1 with furnace No. 1. Some practical experience with the fuels to be used is intended before a final design will be adopted.

The average load of the furnace will be of the order of 250 kg coal per hour; by means of water-cooled pipes to be introduced through holes in the roof the thermal load of the furnace can easily be varied between 20 and 70 per cent.

Air Preheater.—While the availability of an air preheater was an essential requirement for work with pulverised fuel, it was nevertheless decided to provide an installation also able to supply preheated air to the oil and gas-fired furnace and which will enable results to be compared with those obtained with cold air. A separately fired preheater will be fired by blast-furnace gas (max. 1600 cubic metres per hour) and will preheat the air to a maximum of 750 deg. Cent. The heater will be constructed of smooth alloy steel tubes (Schack patent) which are suspended vertically.

General Facilities.—One group of recording and control facilities consists of six universal electronic recorders and one indicator with interchangeable ranges and chart speeds. Some are line recorders, others multi-point recorders. They record all the electrical outputs which are obtained with the furnaces, i.e. radiation and suction pyrometers, thermocouples in walls and roof, heat flow meters, &c. All leads from both furnaces end in a panel from which any recorder can be connected, by means of flexible leads, with any measuring source.

In the gas analysis room the equipment includes two gas analysis recorders for CO_2, which allow rapid surveys of flow patterns in the furnace to be made. Other instruments include two black body radiation furnaces, with potentiometers for calibration of radiation pyrometers; thermocouples and heat flow meters.

The new station will consequently provide every possible facility for experiments on all kinds of flame. Oil, gas, propane, pitch, coal, &c., can be used as a fuel; combustion air with a preheat of maximum 750 deg. Cent., and eventually enriched with oxygen, is available; steam, compressed air and oxygen can be used in any burner. The total cost of the station will be about £60,000.

Electrical Research Association

The thirty-third annual report of the Electrical Research Association, Leatherhead, was presented at the annual general meeting of the Association on April 30th last. On the same day the Association held its annual luncheon. Reference to these events is made here.

THE annual luncheon of the British Electrical and Allied Industries Research Association was held in London on April 30th, when the principal guest was the Rt. Hon. the Viscount Waverley, P.C., the president of the Parliamentary and Scientific Committee. Viscount Waverley, who proposed the toast of "The E.R.A.," said that the occasion offered an opportunity of taking stock on the question of research and of considering whether or not some change of emphasis was needed. He asked whether fundamental research was not, in some cases, being carried rather beyond existing possibilities of application and whether there was not a growing lack of balance as between the numbers of scientists and technologists. Speaking of the industry's research effort, he said that some of the large firms' contributions to the Association's research effort was small compared with their own direct research contribution. If this was so, it was a short-sighted policy, for the prestige of the industry as a whole, especially in export markets, was of interest to all its members. It was possible that a modest increase in the contributions made by the larger manufacturers would bring more than modest benefits to the industry.

Sir Lawrence Bragg, resident professor, the Royal Institution, and president of the E.R.A., responded on behalf of the E.R.A., and the toast of "The President" was proposed by Mr. C. T. Melling, chairman of the council of the Association.

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The annual report, which was presented at the annual general meeting, dealt with the activities of the E.R.A. during the year ended December 31, 1953. It was pointed out in the report that during the first quarter of 1953 the Association applied to the D.S.I.R. for a capital grant of £100,000 towards the new laboratory buildings at Leatherhead. On September 17th the D.S.I.R. notified the Association that the Government were prepared to make a grant of up to £100,000 subject to various conditions. The most important of these were that the Association should meet £100,000 of the cost from its reserves before any Government grant was spent, and that the total capital contributions paid by or guaranteed from members should attain £200,000. Capital contributions did not yet quite reach £200,000, but the council confidently believed that the further approaches, which were being made to members who had not yet guaranteed a contribution, would produce the sum required.

The contract with the main contractor, Messrs. Gee, Walker and Slater, of Park Lane, London, was sealed on November 17, 1953.

The following abstract from the report outlines the scope of the Association's research effort.

Research

The main research effort in relation to generation is concerned with high-temperature alloy steels. This is to be expected, since generating plant is being ordered for temperatures and pressures for which long-term creep and relaxation tests on the steels are not yet complete. These tests must extend from 10,000–30,000 hours and are made by the N.P.L. in co-operative investigations supported not only from E.R.A. general funds but also by the British Iron and Steel Research Association, turbine makers, boilermakers, tube makers and others. It is hoped in 1954 to increase this work substantially beyond the £10,000 allotted in 1953, and the Association has already received promises of additional financial help, including a promise of assistance from the Parsons and Marine Engineering Turbine Research and Development Association. The investigation of cracks in molybdenum steel steam pipes is complete and will soon be reported.

The E.R.A. has continued its co-operation with the North of Scotland Hydro-Electric Board, the B.E.A. and the manufacturers on the 100kW wind-driven generator already installed and working in Orkney and the 100kW generator probably to be erected in Wales. Both the manufacturers have provided smaller machines for the E.R.A.'s experimental station at the College of Aeronautics and, with the help of the Ministries of Fuel and Power and of Agriculture and Fisheries who support this work, some three further small windmills are being installed there. The wind power survey of the British Isles will soon be complete, apart from work on sites selected for generators.

The sub-committee, of which Sir Eric Rideal is now chairman, provides technical discussion and co-ordination of the E.R.A. programmes and the work sponsored by the B.E.A. and Ministry of Fuel and Power on the direct electrochemical generation of electrical power. The investigators for the E.R.A. at Cambridge on the gas cell made significant progress this year in overcoming the corrosion of the oxygen electrode which so far has limited the life of the cell. Other investigations deal with redox cells and cells with solid electrolytes.

The appropriate authorities are considering the possibility of a trial d.c. transmission at high voltage over a fourth (spare) cable which might be included in the proposed power link between the systems of the B.E.A. and Electricité de France. In the meantime some tests have been made on a submarine cable to the Isle of Wight comprising observation of magnetic fields and their possible effect on navigation. Mr. Calverley, Dr. Lamm (Sweden) and members of the E.R.A. staff gave a series of lectures at the Manchester College of Technology on h.v. transmission using direct current, which drew a large and widespread attendance.

There is increasing interest in the use of series capacitance to improve the regulation and stability of long overhead lines. The main difficulty is to avoid damage to the capacitance when accidental short circuits occur. The Association, in studying this problem, has made full-scale tests on one proposed device.

The main stage of the E.R.A. network analyser has been in frequent service, for example, on the rates of rise of restriking voltages on the 132kV and 275kV systems.

The a.c. discharge detector, now in commercial production, is finding a wide range of application, mainly for the control of manufacturing processes. The instrument differs from others in its ability to measure the energy dissipation in individual voids and is expected to improve estimation of long-term service life. The dispersion meter will shortly be commercially available. There is increasing interest in the use of this instrument for the determination of the end point in drying paper insulation. Like the discharge detector, the dispersion meter was developed mainly for testing insulation in service. Application during manufacture raises fewer problems since standards of what is acceptable are more readily defined.

To obtain a correct interpretation of circuit interruptions caused by lightning, some knowledge of the degree of attenuation of surges with distance is essential. Tests were made many years ago on high-voltage lines mounted on steel towers, but information for low-voltage lines mounted on wood poles has in the past been lacking. Through the courtesy of the Southern Electricity Board the Association was enabled during the year to make attenuation measurements on an 11kV line.

The Association has further pursued its improvements to the a.c. air break arc chute type circuit breaker by means of high-power proving station tests. High-power tests were also made on the measurement of post-zero current in an a.c. arc broken by an experimental gas blast circuit breaker. The facilities for contactor researches have been expanded

for both a.c. and d.c. breaking capacity and wear tests.

A paper on methods for calculating axial electromagnetic forces in unsymmetrical transformer windings, together with an account of the methods of experimental verification is in course of publication. The main investigation now includes the effect of the ratio of the length to the diameter of the windings. As part of the general investigation of thermal problems in transformers, a device has been developed to measure ambient temperature in such a way that the measurement reflects accurately the effect of variation of ambient temperature on the temperature rise. It has been demonstrated that this device gives the same degree of accuracy as the maintenance of constant ambient temperature.

The industrial interest in the heat pump is now such that the E.R.A., although it continues its full-scale trial at the Shinfield Field Station and its studies of more efficient components, can now concentrate on favourable applications where a double purpose can be served. One example is where a heat pump cools the larder and heats water for the sink, and another example is in cooling milk and providing hot water for washing utensils. The former was exhibited at the Building Exhibition (Olympia) and at St. Albans ; the latter was shown at the Shinfield open days.

Similarly floor heating by buried electric resistance wires, using the thermal storage of the building, is now in commercial development and the E.R.A. co-operates (particularly with Area Boards) in controlled and adequately instrumented studies in various parts of the country. The thermal storage unit based on latent heat, mentioned last year, has been further developed.

The extensive new installations (including a new road) for studying pressure piling in large flameproof motors while running are now complete and test motors are available so that results are now being obtained. The investigations on intrinsically safe circuits and on flange gap protections have led to conclusions tentatively accepted for international as well as British standards. Hitherto work on hazardous atmospheres has borne particularly in mind the conditions involved in coal mining, but the problem of industrial hazards of this kind is far wider. The Ministry of Fuel and Power has initiated discussions, in which the E.R.A. has taken part, in order that the broader problem shall be treated on a correspondingly broader basis.

In collaboration with the British Welding Research Association, study of arc length control in self-adjusting welding arcs has led to the development of improved d.c. and a.c. power sources, with low open circuit voltages and flat outputs, which permit a high degree of self-adjustment and simplicity in operation. Further development of the surge injector unit includes the a.c. self-adjusting arc as well as the argon arc.

Work on low-voltage platinum contacts has shown the existence of several kinds of discharge, including transient arcs, at very low circuit inductances. The transfer of metal from one contact to another, arising from discharges, can be minimised by adjustment of the circuit constants.

The Ministry of Agriculture and Fisheries continues to support the E.R.A.'s work on rural electrification. Apart from basic researches on crop drying, during which a very simple moisture meter has been developed, the success achieved with portable electric weed killers on seedlings has led to a larger experiment on killing bracken, now in progress. New cables are being tried with the electric tractor since cable performance is the limiting factor.

The year's work has confirmed the advantages of artificially illuminating tomato seedlings and has also advanced mixed soil and space heating of tomato plants which can yield great savings. A wide variety of other soil-warming experiments were continued as well as glasshouse studies, including an automatic method of shading. Promising results on h.f. methods of destroying weevils in stored grain have led to the study of higher frequencies. The E.R.A. collaborated with the Ministry and the Scottish Home Department on electric fishing.

The theoretical and experimental studies of ferro-electrics at Bristol have led to a better understanding of structural transitions and behaviour of polycrystalline materials, but to make further progress on electrical properties an investigation at Leeds is being supported where large single crystals have already been grown and examined. Although the work at Perivale on possible new ferro-electrics has been negative, it has made an important contribution on the relation between semi-conducting and ferro-electric properties.

In discharge breakdown attention has been concentrated on the propagation of failure from local stress concentrations. Once channels have started they will grow if the intrinsic electric strength is locally attained, and this mechanism seems to apply to short-time industrial breakdown tests. With the sponsorship of the Ministry of Supply work has begun on the deterioration by discharges of plastics cross-linked by neutron irradiation. The extensive research on capacitors, supported by the Ministry of Supply, has included the substantial completion of work on stabilised chlorinated impregnants, increase of discharge inception voltage of oil-impregnated capacitors, failure of mica capacitors and the development of a dry oxide dielectric film which seems to have important potentialities.

Among the most important contributions which the E.R.A. can make is in providing methods of study and test of industrial insulants and these are ultimately incorporated in British or international standards. This year's effort has included varnish fabric (particularly glass fabric), fabric and plastic sleevings for heavy plant, tracking of varnish and other impregnants or finishes, cotton-covered wire where the lubricants in spinning have been found to have an effect and insulating films based on silicones, P.T.F.E. (polytetrafluorethylene) and P.C.T.F.E. (polymonochlortrifluorethylene). Special attention has been paid to insulating oils in connection with the use of inhibitors, maintenance, oxidation and saponification, copper contamination, and both the intrinsic and industrial electric strength, including the effect of pressure. Most aspects of the work on insulation have figured in the assistance given to I.E.C. committees during the year.

Members are now trying recommended methods of improving the stability of moulded carbon-loaded resistors and the investigation, supported by the Ministry of Supply, is being extended to other types of resistor.

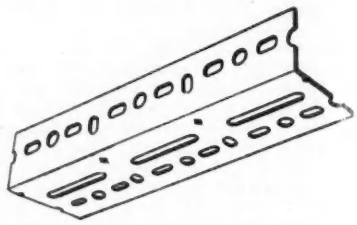
Work at Oxford on the hollow cathode is complete and attention turned to cathode mechanisms in arc discharges. A considerable advance in the theory of the concentration of an a.c. arc was made at Perivale during the year. The general theory of the ionisation and radiation from discharges has been pursued at Liverpool. A new theory of breakdown at microwave frequencies has been developed at Durham and will be tested by experiments with high-frequency pulses of from 1 microsecond to 1 millisecond duration.

The British Iron and Steel Research Association is undertaking some fundamental research on transformer steel under a joint B.I.S.R.A.–E.R.A. Committee. On the measurement side University College workers have measured the losses in several grades of silicon iron sheet up to inductions of 23,000 gauss. Nottingham University investigators are making an extensive study of domain formations in single crystals of silicon iron. The Permanent Magnet Association Research Laboratory has reported an unexpected magnetic ageing of Alcomax and related alloys when taken to sub-zero temperatures of −50 deg. to −70 deg. Cent.

General Purpose Slotted Angle

A RECENT development in the use of slotted angles for general light structural use has recently been introduced by Dexion, Ltd., Triumph House, 189, Regent Street, London, W.1. The idea behind this kind of construction is to have a standard slotted angle which can be cut to length, as required, and assembled by bolting. The slotting has therefore been devised to meet as many possibilities of erection as possible, such as splicing two lengths of angle together, making a rigid three-dimensional corner, or a pin joint. The new system has also been introduced with a light angle, for which, the company states, there is a considerable demand.

The system of slots consists of a double row on the wider leg of the angle, and a single row on the narrower leg, as illustrated. The diamonds are at 3in intervals, and it is intended that the angle should be cut on a diamond. Mild steel



General Purpose Slotted Angle

bolts, $\frac{3}{16}$in in diameter, are used for jointing, and the angle size is 2½in. by 1½in. by 0·080in by 14 oz. per foot, in steel, and 5½ oz. per foot in aluminium. The inner row of slots on the wider leg consists of similar slots, each $\frac{11}{16}$in wide. The other two rows are based on a $\frac{3}{8}$in diameter. The steel angles have a 0·1 per cent proof stress of 15 tons per square inch, and the maximum permissible tension in an angle is 1·8 tons. The steel angles are stove enamel finished, over phosphate rust-proofing.

Set for Circular Saws

A NEW saw set which has been introduced by James Neill and Co. (Sheffield), Ltd., Napier Street, Sheffield, 11, for setting the teeth of circular saws up to 10 gauge, is illustrated below. With this tool, as with the other saw sets made by the firm, the teeth of a saw are uniformly set simply by applying the jaws to each tooth in

Circular Saw Set

turn and squeezing the handles after the initial adjustments have been made.

The depth of set is controlled by turning a small knurled nut behind the jaws of the tool. This nut positions a tooth stop which determines the depth of set from the top of the tooth, and this depth is indicated by a scale in sixteenths of an inch which is engraved on the anvil. The amount of the set is controlled by means of the large graduated thimble on one handle of the tool. As the amount of set naturally varies according to the size and type of the saw and the timber to be cut this adjustment must be ascertained by trial. Once the required set has been determined the reading in the graduated thimble is noted for future setting purposes.

Horizontal Boring, Facing, Milling and Drilling Machine

A NEW 5in-spindle horizontal boring, facing, milling and drilling machine equipped for screw cutting, now being made by Craven Brothers (Manchester), Ltd., Reddish, Stockport, is illustrated on this page. This traversing spindle machine has a large faceplate with a built-in facing slide. It is fitted with grouped controls and quick power-operated traverse for all motions.

The spindle and faceplate of the machine can be driven individually or together at the same or different speeds as required. Means of feed and quick power traverse are applied to the spindle and the facing slide, to the spindle slide vertically, and to the table longitudinally, transversely and rotationally. Selection can be made either for boring feeds in inches per revolution of the spindle or for milling feeds in inches per minute. For the boring feeds the necessary motion is derived from the main spindle rotation, and for the milling feeds from an independent 4 h.p. motor mounted on the spindle slide. A 7½ h.p. motor at the base of the column supplies the quick power traverse for all motions.

The three-shear bed is of sufficient width to give full support to the table even in its extreme transverse positions, the centre shear providing a long narrow face for guiding the table saddle. The left-hand end of the bed forms a wide base to support the massive column which, in turn, has wide vertical slideways to carry the spindle slide. The spindle slide is balanced by a weight inside the column and is traversed vertically by means of a large-diameter feed screw situated between the column slideways. A steel rule and vernier scale fitted on the column ensures accurate vertical setting, and, if required, a measuring bar holder and precision dial gauge can be supplied.

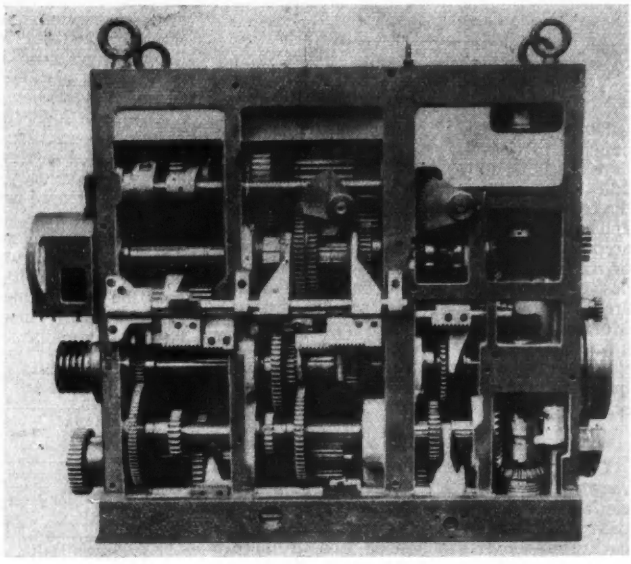
The box shaped spindle slide houses the main spindle and faceplate drive and all the speed and feed change gearing. As a matter of interest we reproduce a photograph of this spindle slide with the front covers removed. It carries a 15 h.p. constant-speed, flange-mounted main driving motor, which is directly coupled to the first motion shaft in the gearing. No friction clutch is included for engagement of the drive, forward or reverse rotation and inching motion in either direction being effected by push-button control of the main motor only. An automatically operated solenoid brake, acting on the motor shaft, quickly brings the spindle and faceplate to rest after the motor stop button has been pressed.

The 5in diameter spindle is supported in a long driving sleeve running on ball and roller journals, and has axial feed and quick power traverse. Final drive is transmitted through a sleeve gear mounted on its own bearings and keyed to the spindle driving sleeve, an arrangement designed to eliminate journal thrust and subject the spindle to torque only. A long second concentric sleeve, also mounted on ball and roller bearings, carries the faceplate, the final drive to which is through a spur pinion and internal gear ring.

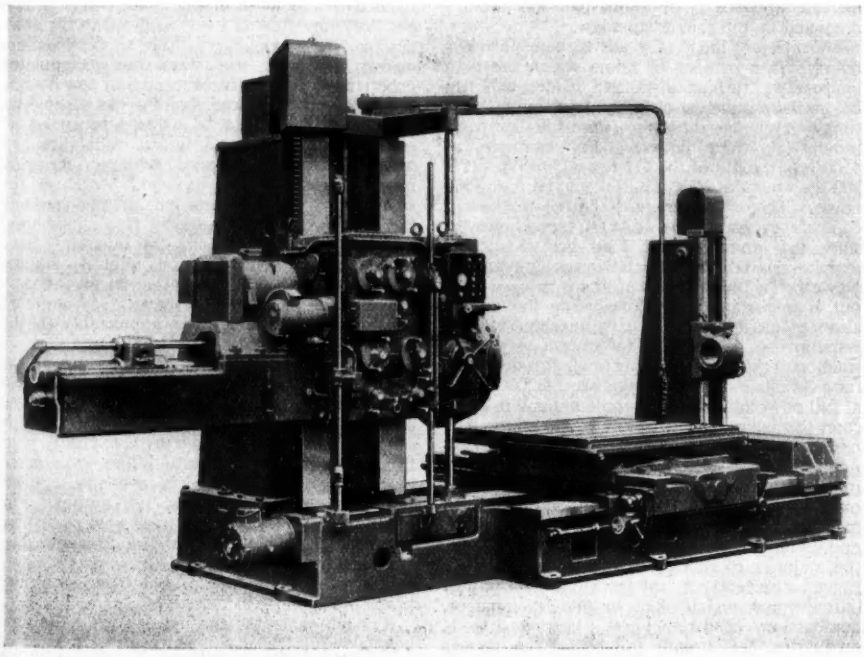
The facing slide is built into the faceplate and its feed and adjustment are transmitted through differential gearing. Provided that the spindle has been retracted beneath the surface of the faceplate, it is possible to face down to the central axis without difficulty. Work up to a maximum diameter of 50in can be faced on the machine.

The tee-slotted, rectangular work table has a 60in by 72in work surface and is surrounded by a channel for the collection of spent coolant fluid. It is mounted upon a transverse saddle slideway and can be rotated either by hand or power both for feeding and rapid setting. The circular base flange is engraved in degrees, and the table can be clamped in any required position, additional positive indexing being provided for the four main positions. The table has automatic cross feed and both hand and quick power traverse upon its saddle. The saddle can be fed or quick traversed along the bed either by hand or power, and adjustable trip dogs can be set to limit the traverse in each direction. The table can be clamped to its saddle or the saddle to the bed, as required.

Fine hand feed to the spindle, facing slide, spindle slide and table is effected by a single star hand wheel, which is easily disengaged when the rapid power traverse is operated. An indicator dial is graduated to register all adjustments, and separate levers select the particular traverse and direction desired. Power feed for any motion is engaged by the same main control lever, whilst a further lever selects for boring or milling feeds and operates an electrical interlock to ensure that the milling feed motor is not started while the boring feed drive is engaged. Further interlocks prevent the selection of quick power traverse or automatic feed whilst the star hand motion is in gear. Should the main motor stop during milling operations, the milling feed motor stops automatically. Pre-set trip mechanism can be used to limit the travel of the spindle slide vertically or the table longitudinally or transversely.



Spindle Slide Mechanism of Boring Machine



5in Horizontal Boring, Facing, Milling and Drilling Machine Equipped with Screw Cutting Motion

Push-button controls for all the electric motors are grouped together in a conveniently placed panel on the front of the spindle slide. This panel incorporates an ammeter to indicate machine load, a danger mark being shown on the scale to give warning of overload. Coloured lights show the direction of main motor rotation and that the milling feed motor is running. A pendant push-button station, mounted on a swivelling arm overhanging the work table, duplicates the main motor and quick power traverse motor control buttons.

A hinged outer bar support bearing facilitates the removal of boring bars and adaptor bushes. It has means of both fine hand adjustment and power traverse vertically on its support column, which has a rule and vernier scale for accurate setting. The column is mounted on a substantial tee-slotted base which spans the full width of the bed ways. Removal of the column allows its base to be used for the support of extra long workpieces. The whole assembly can be moved along the bed by power and clamped in any required position; alternatively, it may be completely removed from the machine where a longer table travel is required or outsize work has to be accommodated.

When fitted with a constant-speed main motor the machine has twenty-eight spindle speeds ranging from 2·8 to 300 r.p.m. through the change gears in the spindle slide, and sixteen faceplate speeds ranging from 2·8 to 37·5 r.p.m. If preferred, a two-speed motor can be used, which gives a total of thirty-two spindle speeds

from 2·8 to 600 r.p.m. and twenty faceplate speeds from 2·8 to 75 r.p.m. The range of spindle height setting in respect of the table top is from 50in to 3½in, while the maximum horizontal traverse of the boring bar at one setting is 40in and at two settings 60in. The maximum distance between the faceplate and the boring bar support bearing is 10ft, and the available travel of the table longitudinally, with the boring bar support in position, is approximately 48in. With the support removed, however, the travel of the table is extended by a further 14in.

There are eighteen boring feeds from 0·0009in to 0·25in per revolution of spindle or faceplate; twelve milling feeds from 0·56in to 25in per minute; and eighteen facing feeds from 0·001in to 0·4in per revolution of faceplate. The vertical feed to the spindle slide can be combined with the horizontal transverse feed of the table, enabling faces to be milled at an angle of 45 deg.

British Naval Gas Turbines*

By Commander (E) G. F. A. TREWBY, R.N.

DURING the past ten years six different designs of naval gas turbine have been developed and tested under Admiralty contract and a further two designs have been brought direct from the manufacturers for evaluation and testing. This paper gives in turn a brief account of the development and manufacture of the eight gas turbines and describes special design items. Details of operating experience are given and the lessons learned are discussed. More power in less weight and space is the main advantage of the gas turbine for warship application, it is stated; hence the gas turbines must be built on the open-cycle principle with light scantlings.

GENERAL CONCLUSIONS

Characteristics and Type of Construction Required for Naval Gas Turbines.—The problem confronting the Navy in the gas turbine field has been to determine how the characteristics of this new prime mover can best be used to improve the fighting efficiency of the Fleet. This is no easy matter, since gas turbines can be built in a bewildering variety of forms, each possessing widely different characteristics. Moreover, naval requirements are, in general, very different from those of industrial, merchant marine or aircraft applications.

As a result of the experience obtained to date, the author considers that the greatest single advantage which the gas turbine can offer for naval applications is its ability (particularly in the simpler forms) to pack more power in less weight and space than any other prime mover. To achieve this characteristic, an open-cycle plant is essential and this type also lends itself to the maximum amount of development in the future. But it is also necessary to construct the gas turbines on lightweight lines. Looking at the specific weights in Table II, the great difference between the aircraft type gas turbines and the E.L.60A, which adheres closely to steam turbine practice, is at once apparent. The heavy type of construction is also more prone to thermal distortion and reduces manœuvring flexibility. This does not imply that the aircraft designs described above are considered ideal for future naval machinery and, in most cases, they were only accepted in order to obtain early operating experience. Reliability would be improved by fitting plain sleeve bearings in place of ball bearings and the temperatures, stresses and corrosion allowances need modification for longer life. In short, the whole engine (including auxiliaries and control gear) must be made more robust. But it is nevertheless considered essential to base the design of naval gas turbines on the aircraft approach, with increased scantlings and modifications where necessary, rather than to follow in the tradition of established steam practice. Unless this is done, the important military advantages of reduced weight and space, rapid starting and great flexibility in operation may never be realised.

Assuming that the design of future naval gas turbines is based on the lines indicated above, the major factors likely to influence their use in warship applications are discussed below.

Performance.—The high fuel consumption of the simple gas turbine, particularly at low powers, is clearly shown in the performance curves of the "Gatric" and "G2." These engines are based on aircraft designs which are now over ten years old, however, and with modern components, fuel consumptions below 0·7 lb per s.h.p. per hour at full power could be obtained with reasonable life. To effect this improvement a higher compression ratio is necessary, which tends to reduce flexibility and may create compressor blade vibration problems. By splitting the compressor (twin spool design), higher compression ratios can be achieved with improved flexibility and fuel consumptions below 0·6 lb per s.h.p. per hour could now be obtained with this type of design. These developments will not alter the steeply rising performance characteristics of the simple gas turbine, however, and consumption figures at half load will remain some 25 per cent higher than at full power. Simple engines on their own are, therefore, intrinsically unsuitable for applications where economy at low power is required.

To obtain higher efficiencies and to improve part load performance a more complex cycle with heat exchange and intercooling is necessary. The great superiority in part load efficiency of the R.M.60 compared with the G2 should be noted. This improvement has been obtained at the expense of considerable complication and an increase in specific weight from 2·28 lb to 5·3 lb per horsepower. It is also interesting to compare the performance of the R.M.60 with the original steam machinery fitted to H.M.S. "Grey Goose," as shown in Table I.

TABLE I

		R.M.60	Steam machinery
Total s.h.p.		10,800	8,000
Weight		5·3 lb per h.p.	14 lb per h.p.
Specific fuel consumption lb per s.h.p. per hour	Full power	0·66	0·88
	½ power	0·61	1·03
	1/6 power	0·76	1·56

Aerodynamically, the R.M.60 is certainly capable of further improvement in performance, but the introduction of plain sleeve bearings to increase reliability and give longer life would involve serious losses in a cycle of this type, particularly at part load.

Before leaving the subject of performance it is worth noting that the specific weight of simple gas turbines increases with power. Theoretically, this increase should follow the "square-cube law," e.g. if an engine were scaled up from 5000 h.p. to 10,000 h.p., its specific weight should increase by $\sqrt{\frac{10}{5}}=1{\cdot}4$ times. In practice the increase appears to be about half the amount predicted by the square-cube law.

Life.—The "life" of a gas turbine normally refers to the number of hours which the high temperature turbine discs and blades will run before there is danger of failure from creep. In a simple cycle gas turbine this life increases rapidly at lower powers. For example, at 4500 h.p. the life of the G2 (on a creep basis) is 300 hours, but at 3500 h.p. it would be over 2500 hours. This characteristic is not so marked in complex cycles of the R.M.60 type, however, since the improved part load performance is mainly achieved by a slower fall in gas temperature. Nevertheless, the increase of life at reduced output is important when considering the application of gas turbines to naval machinery, for a warship uses high power for only a very small fraction of the total operating time. It is doubtful, for example, if many warships exceed 2000 hours at full power during their whole life and in some cases this figure may be as low as 500 hours. For naval propulsion machinery, therefore, the full-power life can be extremely short, judged by industrial standards, and there is only a requirement for longer life at reduced output. Even main generators seldom operate at full power, and, although detailed records are not available, the majority of running probably occurs in the range between 50 per cent and 80 per cent power.

In the present state of gas turbine development, combustion chamber liners, bearings, seals, auxiliaries, &c., usually fail before the engines are "life expired" on a creep basis. From the mechanical point of view, however, there is no fundamental reason why the lightweight construction advocated above should not be capable of giving reliability and long life in all components except the "hot parts." The overhaul periods would then be controlled by the combustion chamber liners and the "creep life."

Effect of Ambient Temperature.—Gas turbine performance is extremely sensitive to ambient conditions and stated figures of power or efficiency mean little unless associated with a definite temperature and pressure. In the G2 the maximum power reduces from 4500 h.p. to 4000 h.p. with an increase in inlet air temperature from 15 deg. Cent. (59 deg. Fah.) to 27 deg. Cent. (81 deg. Fah.). This large variation in performance may give rise to difficulties in naval vessels which must operate satisfactorily in arctic or tropical climates. The size of gas turbine will usually be fixed by the output specified for tropical conditions, and in cold climates considerably more power will theoretically be available at the same gas temperature. To take advantage of this power it is necessary to stress the turbine, gearing, shafting, and propellers accordingly, which results in a heavier installation.

There are obvious advantages in quoting all gas turbine performance figures at a standard temperature and a figure of 15 deg. Cent. (59 deg. Fah.) is used throughout this paper. When specifying the ambient conditions for naval gas turbines it should be borne in mind that propulsion machinery can only be run near full power in the open sea, where the air temperature seldom exceeds 33 deg. Cent. (91 deg. Fah.), whereas main generators may be required to develop full power in land-locked tropical harbours where the air temperature is considerably higher.

Duct Sizes.—Gas turbines require much larger quantities of air than other prime movers. Compare, for example, the air rate of the R.M.60 (70 lb per h.p. per hour) or the G2 (87 lb per h.p. per hour) with average figures for diesel machinery or steam turbine plant (11 lb and 14 lb per h.p. per hour respectively). This situation is aggravated by the greater sensitivity of gas turbines to inlet and exhaust pressure losses. (The power falls approximately 10 per cent for each 1 lb per square inch inlet pressure loss and by 5 per cent for each 1 lb. per square inch exhaust pressure loss. A pressure loss of 1 lb per square inch in either the inlet or exhaust causes approximately 5 per cent loss in efficiency in addition to the loss of power.) The large duct sizes necessary in gas turbine installations are a disadvantage, since they take up valuable space, and the increased sizes of deck opening are a source of structural weakness and increase the vulnerability to battle damage.

Reliability and Maintenance.—The naval gas turbine is still in its infancy and many defects and teething troubles have occurred in the early designs. Basically, it is the simplest of all engines, however, and when the accumulated experience to date is incorporated in new designs the author is convinced that the gas turbine (in its simple forms) can be made superior to all other prime movers as far as reliability and maintenance are concerned, without sacrificing its very high power-weight ratio. Moreover, the small size of components will greatly facilitate their removal and replacement for maintenance.

The more complex cycles will inherently have somewhat less reliability, but should compare favourably with other engines. It also appears that a heat exchanger designed for minimum weight and space may add appreciably to the maintenance commitments.

Flexibility and Control.—The majority of gas turbines described in this paper have independent (free) output turbines, giving flexibility of torque and speed over the whole power range. This characteristic is essential for propulsion with fixed pitch propellers, but at idling speed some residual torque will always be available, equivalent to about 3 per cent of full output. For generator applications a free power turbine improves part-load efficiency, and enables the machine to accept sudden overloads in emergency without stalling; but the governing problem is greatly increased.

A single-shaft gas turbine delivers no power below about 30 or 40 per cent of maximum speed, and this type will normally be confined

* Institute of Marine Engineers. April 13th. Abstract.

to constant-speed machines such as generators. It does appear feasible, however, to operate a single-shaft design as a propulsion engine with a controllable-pitch propeller, but this arrangement would be most uneconomical for low-speed cruising.

It has been effectively demonstrated in the Gatric, G2 and Rover T.8 installations that gas turbine controls can be reduced to a throttle lever and starting switch. This simplicity has obvious operational advantages.

Production Costs.—An assessment of production costs at this early stage in the evolution of naval gas turbines may be misleading, since manufacturing experience is very limited and any new design may involve considerable development. Nevertheless, the present cost of manufacturing a proven design of simple engine in small numbers should not exceed £15 per horsepower, which compares favourably with other prime movers ordered to special requirements.

The production of lightweight gas turbines involves precision machining to high standards of accuracy, but is well suited to mass production in time of war. If the numbers justify full-scale tooling-up the cost of simple cycle naval gas turbines should approach that of aircraft propeller turbines, which are currently being manufactured for about £7 per horsepower.

Fuel.—The gas turbines described in this paper will operate satisfactorily on a wide range of distillate fuels, including Admiralty diesel (gas oil) and aviation kerosene, but they can only burn residual fuel for short periods in emergency and then only if suitable heating equipment is provided.

There are many naval applications where distillate fuel is acceptable, but it is generally assumed that before gas turbines can replace steam installations for the main propulsion of large warships they must be capable of burning residual fuel. The burning of residual fuel in open-cycle gas turbines presents formidable problems, the most important being deposition and corrosion of the turbine blades by inorganic constituents in the ash. A large programme of research and development is being directed to the solution of these problems and a Ruston and Hornsby 750kW TA gas turbine alternator will shortly be installed at the Admiralty Test House, N.G.T.E., with the object of carrying out extensive trials on the burning of residual fuels. It appears that by controlling combustion and using small quantities of additives in the fuel both deposition and corrosion may ultimately be reduced to acceptable limits. However, little practical experience in burning residual fuels at the high temperatures necessary for naval gas turbines exists.

Reversing.—In steam installations reversing is provided by a separate astern turbine, which idles in the condenser vacuum during ahead running. There is no such vacuum in a gas turbine, so that windage losses would be excessive. In addition, there would certainly be difficulty in keeping the control valves gastight at high temperatures and the complicated ducting necessary might compromise ahead performance. If gas turbines are to be used as the sole means of propulsion, some external means of reversing is therefore essential. Possible methods of providing this reversing are :—(*a*) Electric drive, (*b*) controllable pitch propellers, (*c*) mechanical reversing gears, (*d*) hydraulic reversing couplings, (*e*) separate lightweight gas turbine for astern use only.

A detailed discussion of these methods is outside the scope of this paper, but it is worth mentioning that (*e*) is only practical when the astern power required is a small fraction of the ahead power. Experience with (*b*) will be obtained in " Grey Goose," and (*c*) has been used successfully in Harbour Launch No. 3964.

Noise.—High-intensity noise appears to be inherent in the design of gas turbines approaching the required standards of lightness for naval applications. The majority of this noise emanates from the compressor inlet and the exhaust, where silencing can be readily applied. At the compressor inlet the noise is usually of high frequency, consisting of fundamental and harmonics of the number of blades per row times the speed of rotation. Noise from this source can be reduced simply and effectively by fitting splitters and by lining the inside of the duct with sound insulating material. In M.G.B. 2009, for example, this procedure resulted in a noise reduction of 39 decibels from the original level of 117 decibels. At the exhaust, noise covers a wide band of frequencies, and can best be silenced by reducing gas velocities, by fitting torpedo splitters, and by lining the funnel with silencing material.

Future of the Naval Gas Turbine

The gas turbine will only supplant existing machinery in warship applications where it is shown to be generally superior, based on the special naval requirements. The only true criterion for comparison is service experience at sea, and this is unfortunately still extremely limited, but sufficient knowledge has been gained from the projects described above to indicate the future of the gas turbine in the Royal Navy with some confidence.

In the author's opinion, gas turbines will be introduced in increasing numbers for the propulsion of high-speed coastal craft. In major warships the first applications will be as " boost " units for use at high powers with steam turbines or possibly diesel machinery for cruising. At a later stage gas turbines may become the sole means of propulsion in some warships. Gas turbines will also be found in certain landing craft and ships' boats in the near future. Turning next to the auxiliary machinery field, gas turbine generators for normal or emergency use will be fitted in increasing numbers and gas turbine portable pumps introduced for fire fighting and salvage.

There are other naval applications, not yet fully explored, where the characteristics of the gas turbine may show to advantage. Among these are boiler blowers, de-icing equipment for use in arctic regions and the provision of low-pressure air for salvage and other purposes.

Looking further into the future, the partial supersession of existing machinery by gas turbines may well prove as revolutionary as the change from reciprocating engines to steam turbines at the turn of the century.

TABLE II—*Design Details of British Naval Gas Turbines*

Column number	1	2	3	4	5	6	7	8
Engine	Gatric	G2	E.L.60A	R.M.60	T8	Artouste I	1000kW.G.T.A.	Emergency G.T.A.
Maker	Metropolitan Vickers and Co., Ltd.	Metropolitan Vickers and Co., Ltd.	English Electric Co., Ltd.	Rolls-Royce, Ltd.	Rover Motor Company, Ltd.	Turbomeca (Blackburns)	W. H. Allen, Sons and Co., Ltd.	W. H. Allen, Sons and Co., Ltd.
Maximum power at 15 deg. Cent. (60 deg. Fah.) air inlet temperature, h.p.	2,500	4,500	6,500	5,400	200	276	1,512	200
Duty	Boost propulsion	Boost propulsion	Main propulsion	Main propulsion	Craft propulsion	Utility	Main generator	Emergency generator
Cycle (see Note 1)	1/LP	1/LP	1/P/E	2SC/1P/IE	1/LP	1/C	1/LP/E	1/C
Turbine inlet temperature at maximum power : Deg. Cent.	750	800	704	827	847	800	650	750
Deg. Fah.	1,382	1,472	1,299	1,521	1,557	1,472	1,202	1,382
Overall pressure ratio	3·5	4·0	4·02	18·5	4·0	3·7	4·25	2·65
Air flow at maximum power, lb per sec	47·5	65·6	128	64·6	3·5	4·75	37·1	5·7
Thermal efficiency at maximum power	12·8	17·2	20·4	20·4	12·5	13·75	19·75	12·9
Thermal efficiency at 50 per cent power (See Note 2)	9·5	13·4	17·75	22·6	9·2	9·8	15·6	7·5 (Design values)
Specific weight, lb per h.p. at maximum power (See Note 3)	2·77	2·28	27·2 excluding bedplates	5·3	2·25	0·78	10·5	3·0
Designed life of hot parts, hr. (based on creep data)	300	1,000	10,000	1,000	800	500 (estimated)	50,000	1,000
Compressors : Number and type	1 axial	1 axial	1 axial	1 l.p. axial 1 h.p. 2-stage centrifugal	1 centrifugal	1 centrifugal	1 axial	1 centrifugal
Number of stages	9	11	15	11/2	1	1	13	1
Turbines : Number and type	2 axial	2 axial	2 axial	3 axial	2 axial	1 axial	2 axial	1 radial
Number of stages	2/4	1/3	6/6	1/2/2	1/1	2	2/1	1
R.p.m. ÷ 1000	7·4/3·6	7·83/5·2	4/3·6	15/11/7·18	4/35	35	8/6·75	23·5
Number of intercoolers and thermal ratio	None	None	None	3 (l.p. 2 in parallel): l.p. 86 per cent, h.p. 64 per cent	None	None	None	None
Heat exchanger thermal ratio, per cent	None	None	75	48 at full power with bypass open	None	None	70	None
Number and types of combustion chambers	One annular	One annular	Six cans	Two cans	One single can	One annular	Eight cans	One single can

NOTE.—1. Cycle notation adopted from Mallinson and Lewis's paper, "Part Load Performance of Various Gas Turbine Engines Schemes," *Trans.I.Mech.E.* War Emergency Issues 37-46, Vol. 159.
2. With the exception of column 8, thermal efficiencies are actual values obtained on test using Admiralty diesel fuel (gas oil), calorific value 18,500 B.Th.U. per lb. (10,300 C.H.U. per lb.).
3. Specific weights quoted include reduction gearing (when fitted) and all engine-driven auxiliaries.

Diesel Railcars for British Railways

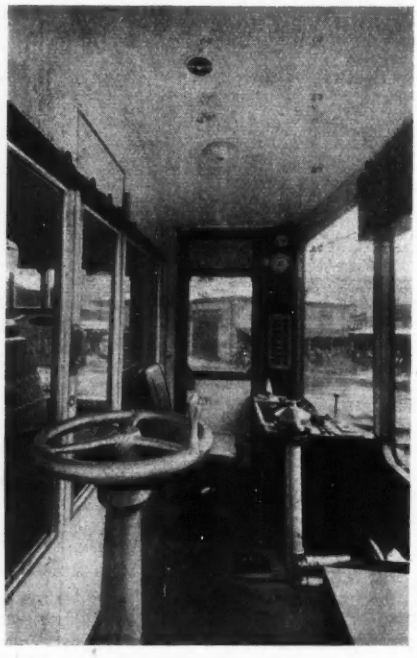
SOME months ago the British Transport Commission announced that a £2,000,000 programme had been put in hand for the development of lightweight, multiple-unit diesel railcars for passenger services on British Railways. The six areas in which it is proposed to introduce these new trains are the West Riding of Yorkshire, West Cumberland, Lincolnshire, East Anglia, Newcastle–Middlesbrough and Edinburgh–Glasgow, where they will partly replace and partly supplement existing steam services. It is expected that the greater economy, flexibility and cleanliness of the railcars on suitable routes in these areas will not only reduce costs, but promote new business.

Except in the case of the proposed Edinburgh–Glasgow route, where the design of the cars will conform to the requirements of a longer-distance inter-city service and will include additional amenities, the basis of the new services will be a two-car set. One vehicle of such a unit will be powered by two horizontal engines of at least 125 h.p. under the floor, and the other a trailer or another motor coach as required. Each two-car set can be driven from either end, and can be operated either as a self-contained unit seating about 130 passengers, or, alternatively, the cars can be assembled into multiple-unit trains of four, six or eight vehicles, according to traffic requirements. This system offers the advantage of being adjustable to traffic demands up to over 500 passengers, while making for economical working when traffic is light.

The first of the new trains to be completed under the new programme was demonstrated last week on a run from Marylebone to Beaconsfield, and this two-car set can be seen in the photographs we reproduce on this page. Light alloys are used extensively in the bodies and underframes of these vehicles, which are fabricated as one unit to combine strength with comparatively light weight. The train demonstrated had two 125 h.p. Leyland engines fitted to each car, as it is designed for service on the steep gradients in the West Riding of Yorkshire. In some of the other areas to be served by these trains only one motor vehicle will be used on each two-car set.

In these new cars all the framing members are of extruded sections riveted together, and the panelling is welded to form continuous sheets from door to door and riveted to the frame members. The floor, of special extrusions, forms part of the structure, and is covered with two thicknesses of flameproof hardboard with an overlay of linoleum. The whole of the inside of the body and the underside of the floor is sprayed with asbestos to reduce condensation and noise.

The interior panelling of flameproof hardboard is covered with P.V.C. cloth, the colour schemes being varied. The seats have frames of tubular steel and are trimmed in maroon moquette in the third-class and blue uncut moquette in the first-class. Luggage racks formed of square section light alloy tubes run the complete length of the compartments on both sides. A lavatory is provided in the composite vehicle of each unit. Train heating is by means of thermostatically controlled oil-burning heaters mounted under the frame and supplying warm air through ducting along the full length of both sides of the passenger compartments at floor level.

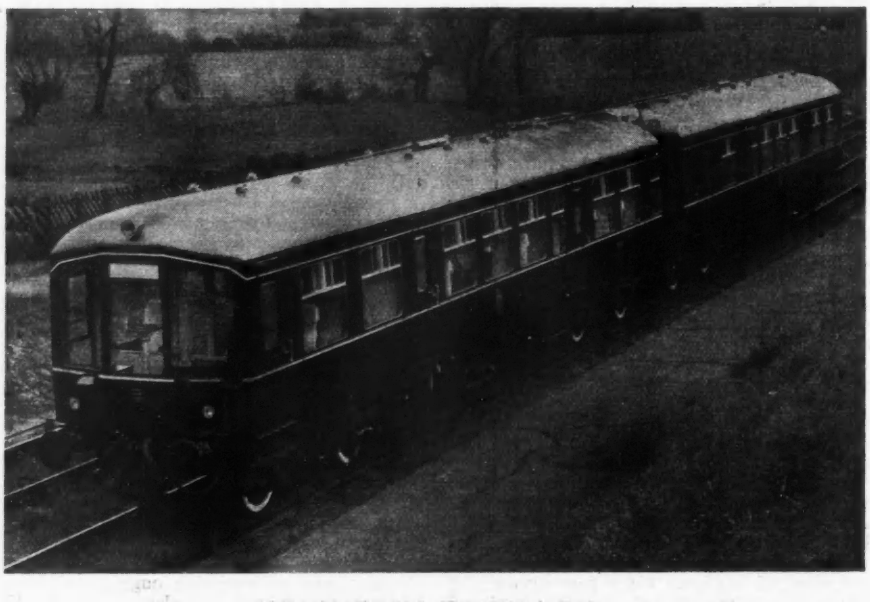


Driver's Cab of Railcar

Bogies of conventional design in mild steel are used with these cars, having the main framing members riveted together, the individual members being partly fabricated. The bolsters are fitted with spring side control, and resilient rubber mountings carry the centre castings and side friction blocks. All axles are carried on roller bearings.

The drive from each of the two 125 h.p. Leyland horizontal diesel engines is transmitted through a torque convertor and "Walker" final drive to one axle of one of the bogies. Each engine also drives an exhauster which provides power for the vacuum brake which is applied by cylinders of standard pattern. The train demonstrated is geared for a normal maximum service speed of 62 m.p.h.

The engines are electro-pneumatically controlled and can all be operated from the driving position at either end of a train set. The control handle is so arranged that should it be released by the driver, after a five-seconds delay the engine speeds will be returned to idling, the torque convertor placed in the neutral position and the brakes applied to bring the train to a standstill. The driver is provided with a speed indicator, engine revolution indicator and window wiper; his seat is adjustable and all controls are within easy reach. As can be seen from our illustration of the driver's cab, he has an unobstructed field of vision and glass panels at the rear of the cab give passengers a view of the road ahead.



Lightweight Two-Unit Diesel Railcar Train

Industrial Trucks and Methods

THE first National Convention organised by the Institute of Materials Handling took place at the Central Ordnance Depot, Didcot, on Thursday, April 29th, under the chairmanship of Mr. A. Fraser Much. Nearly three hundred delegates and guests attended the convention, the theme of which was "Industrial Trucks and Methods." Delegates were welcomed to the Didcot depot by Major-General Bainsbridge, who spoke of the value of introducing industrial material handling methods and equipment to large military stores establishments, and the economies they made possible in manpower and by space saving.

The first series of demonstrations given during the morning session were concerned mainly with methods and equipment for handling parts stored in pallets by the block storage system. This particular demonstration concluded with the removal of some 56 tons of parts stored in 25-cwt pallets by making forty-nine truck movements in about fifteen minutes, using two fork trucks and two pedestrian-operated pallet trucks. It was followed by other demonstrations, including one of handling pallets on and off railway trucks using a light portable bridge plate between the vehicles and the loading dock platform. Each demonstration was controlled by a mechanical handling expert and by means of a broadcast commentary each movement and the equipment used was explained. Two papers were then read, one entitled "Operator Selection and Training," by Mr. A. C. Cooper, and the other, "Preventive Maintenance," by Mr. A. R. E. Arnot.

The afternoon session of the convention opened with demonstrations of some of the ancillary equipment developed to widen the field of application of the fork lift truck. The attachments shown in operation included a jib, rotating heads for emptying bins or other containers for loose materials, clamp or squeeze attachments for bales, a weighing attachment, a new brick or concrete block lifting attachment, &c. These demonstrations were followed by an interesting session in which a panel of industrial truck manufacturers and designers answered questions put by the audience. The large number and variety of questions asked were indicative of the close interest which had been taken in the demonstrations by the representatives of industry and the Army in the audience.

At the conclusion of the conference Mr. Much said that it was proposed to hold similar demonstrations and meetings in other parts of the country, and manufacturers of other types and makes of mechanical handling equipment were being asked to participate. He expressed the appreciation of the Institute to the manufacturers who had lent equipment and the services of their personnel to make the convention the

success that it undoubtedly had been, and congratulated the secretary of the Institution on his organisation of the event.

In acknowledging the thanks of Mr. Much for making it possible to hold the convention at Didcot Depot, Major-General Bainsbridge said that he was glad to hear that other events of a similar kind would probably be held at other military stores establishments. He said that the Army was looking to industry to solve yet more of its handling problems in the field and he hoped that in future conventions other types of handling equipment would also be demonstrated.

Air Pollution Control in America

By FREDERICK S. MALLETTE, M.A.S.M.E.*

No. II—(*Concluded from page 656, April 30th*)

The earlier part of a James Clayton paper presented to the Institution of Mechanical Engineers last Friday, April 23rd, is here printed. Some reference is made to the history of air pollution legislation in America. Recent work in St. Louis, Allegheny County, New York City, California, Los Angeles County, and Canada is then referred to in more detail. The full paper then studies meteorology, the Donora smog, effects upon health, the development of instruments, problems of the iron and steel industry, control equipment, and socio-economic considerations. Those sections of the paper are not reprinted here.

New York City

THE City of New York has an area of approximately 300 square miles, with a large harbour and many miles of shore line. It is estimated that more than 1000 ships enter and leave the port each month. The city contains about 141,000 multiple-family dwellings which possess about 9000 flue-fed incinerators. Factories in the city range from 30,000 to 50,000 in number, depending on the definition used. On the streets there are approximately 128,000 lorries and 115,000 taxicabs, and there are about 1,250,000 automobiles registered within the city limits. Omnibuses traverse the 5700 miles of roadways. All of these sources add to the atmospheric pollution in the city (Greenburg, 1953).

Studies of the New York pollution problem began about 1928, when Owens recorders were set up in a number of locations in the city. Several other studies followed, one of which, made during the period 1936–38, was most extensive.

The first smoke control ordinance was not adopted until 1949. A Smoke Control Bureau was organised the next year in the Department of Housing and Buildings. In 1952 an ordinance was passed providing for control of all air pollution and for a new Department of Air Pollution Control.

Among the sources of pollution are those mentioned above, plus the power stations, private and municipal, which altogether burn about the equivalent of 10,000,000 tons of coal, of which approximately 97 per cent is bituminous. These utilities also consume enormous amounts of fuel oil and natural gas. Some of the boiler equipment of the city's power plants is forty years old, with poor control over smoke and fly-ash.

Formerly, anthracite coal was used almost exclusively in domestic heating plants, but this has gradually been replaced by bituminous. In 1936–37 the consumption of anthracite and coke was about 11·6 million tons. By 1951 the figure was only 3,000,000. The use of bituminous coal increased to 10,000,000 tons in 1951 from 7·5 million in 1936–37.

Private incinerators, serving about 15 per cent of the city's population, consume 400,000 tons of refuse a year. Most of this equipment is badly designed and operated, and it produces enormous amounts of smoke, fumes, and fly-ash. Rules have been adopted, to become effective on January 1, 1955, which are aimed at bettering this problem.

Vehicular consumption of fuel amounts to about 1·1 thousand million gallons of petrol for passenger cars and approximately 20,000,000 gallons of petrol and diesel fuel for omnibuses.

To handle the gigantic pollution problem created by all these sources, the Department of Air Pollution Control consists of a commissioner, deputy commissioner and secretary, an inspection bureau of twenty-eight field inspectors and two marine inspectors, and engineering bureau of eleven engineers, a research bureau of four chemists, a records bureau, and the necessary clerical assistants.

The air pollution problem in New York City is being attacked vigorously and intelligently. A severe smog episode during November, 1953, spurred public interest and supplied necessary public support. The commissioner, who is both an engineer and a physician, has planned his attack along epidemiological lines, like any other public health problem. Complicating his task are the sources of pollution in bordering States, particularly New Jersey. To resolve this difficulty an interstate agency may result similar to the Interstate Sanitation Commission which handles stream pollution problems for New York, New Jersey and Connecticut.

California

Primarily to meet the needs of the Los Angeles basin in alleviating its air pollution problem, the California legislature passed a law in 1947 which created a control district in every county (Kennedy, 1952). This was necessary because Los Angeles County includes some forty-four incorporated cities. The district is given jurisdiction of the entire county. To activate any district the board of supervisors must publish notice, hold hearings, and find that the air of the county is polluted and that local ordinances cannot be relied upon (only Los Angeles and Santa Clara Counties have so acted, and only the former has an existing enforcement body).

The Act provides for the organisational structure of the district with an executive officer and an independent hearing board of two lawyers and an engineer to hear appeals and grant variances.

The Act further provides for the prohibition of certain air pollutants specifically, but also is made all-inclusive by a clause which forbids the discharge of any contaminant which would constitute a Common Law nuisance.

It also provides that the air pollution control board (the board of supervisors or other governing body of the district) may make rules and regulations which have the force and effect of law. However, the State itself has established standards and has made a violation of the rules a misdemeanour. At first, orchard heaters, which meet a simple standard, and agricultural processes were exempted, but an amendment in 1949 authorised the application of the permit system to orchard heaters. These devices, called "smudge pots," which give off a great deal of smoke and little heat, are used to warm the citrus groves to prevent freezing. Efforts are being made to design a heater which would give off more heat and less smoke, for the pollution created during a cold spell by the more than 1,000,000 smudge pots in Los Angeles County alone creates a problem all on its own.

First Control District.—As soon as the Act became effective the Los Angeles County Air Pollution District was activated. Rules and regulations were adopted, setting up a permit system for both the construction and operation of any equipment which might cause the emission of air contaminants. A "grandfather" clause automatically granted a permit to devices in operation when the rules became effective on February 1, 1948. Detailed plans and specifications must be filed before a permit will be granted for new construction or modernisation.

The rules forbid the excessive discharge of a number of specific pollutants, for example, particulate matter over 0·4 grain per cubic foot at a standard temperature of 60 deg. Fah. and pressure of 14·7 lb per square inch. Emission of sulphur compounds, calculated as sulphur dioxide, in excess of 0·2 per cent by volume is forbidden. Solid products of combustion in excess of 0·4 grain per cubic foot of gas, calculated to 12 per cent of carbon dioxide, are forbidden. Later a rule was adopted forbidding the discharge of dust or fumes in accordance with a sliding scale based upon quantity processed per hour. Examples taken from the rules are given in Table I.

Basing emission on the figures for quantity processed has the advantage of forcing large industries to stricter compliance, the theory being that they can utilise control equipment to better economic advantage and also that their effluents are apt to be more objectionable.

The rules and regulations can be amended by the same procedure of notice and hearing as when first established. This makes for a simpler procedure than going back to the legislature whenever a new pollutant or a better test is found. Similarly, the rules can be made more stringent or may be relaxed depending on the requirements of the problem at the time.

TABLE I.—*Examples of Sliding Scale of Maximum Permitted Discharge*

Quantity process per hour, lb	Maximum weight of discharge per hour, lb
50	0·24
100	0·46
500	1·77
1,000	2·80
2,000	4·14
5,000	6·67
10,000	10·00
20,000	16·19
60,000 or more	40·00

New installations which might be the source of air pollution have been forestalled by the provision demanding detailed plans and specifications. This procedure has also safeguarded industry against the sale of worthless control equipment and has provided the expert advice of the district engineers. The section requiring stack analyses from companies has not only prevented the control district's staff from being overwhelmed with field work, but has made industry conscious of its contribution to the general problem. As from September 1, 1952, district engineers had approved permits for equipment valued at 88,647,500 dollars, of which 11,242,900 dollars were for control.

Permits may be revoked as well as granted. This provides strict control over the careful operation and maintenance of control equipment once it has been installed.

Amendment.—Recognising the fact that air pollution knows no boundaries, the California legislature, in its 1949 session, amended the Act to permit two or more contiguous counties, where control districts have been activated, to consolidate into one district. The cost would be divided among the participating counties in proportion to their population. As yet, no action has been taken to form such a merger, as Los Angeles County has the only activated district. There is, however, current public pressure in several counties contiguous to Los Angeles, as well as in the San Francisco Bay area, to form control districts.

Los Angeles County

With interest now becoming prevalent in the combating of all types of air pollution rather than of smoke or fly-ash alone, smoke control ordinances are being supplemented by broader coverage. Typical of these latter rules are those in force in Los Angeles County, California.

A comprehensive paper on air pollution control activity in the United States must include adequate consideration of the significant accomplishments which have been made in Los Angeles County, during the past seven years. The local problem, which appears to be unique in its characteristics and composition, began to develop during the tremendous industrial expansion (more than 1000 million dollars in new capital investments from 1941 to 1950) and population growth (4,116,901 in 1950) of the period of the second world war. The populace gradually became aware of several objectionable features which detracted from the famous Southern California climate, namely, an intermittent decrease in atmospheric visibility, with which were associated marked irritation of the eyes and upper respiratory tract and unpleasant odour. At the same time two other features became apparent, namely, an accelerated cracking of rubber, most noticeable in the side walls of tyres, and a peculiar damage to vegetation, especially certain garden crops. The relation of these two problems to air pollution was not discovered until later.

Public demand finally brought about the necessary enabling State legislation, and in 1947

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the Los Angeles County Air Pollution District was formed. This body can study the problem regardless of city limits, and it has been given the legal tools to enforce the measures necessary for improving the situation.

This remarkable organisation (Anon., 1950–51), with a staff of over 100 people, and an annual budget of approximately 500,000 dollars, has its own building, equipped with laboratories, engineering quarters, offices and a library. Its inspectors police an area of 4083 square miles.

In addition to enforcement and educational activities aimed at early control of the most obvious sources of smog, a programme of research (Haagen-Smit, 1952) has been carried on at the District Laboratory and also, through contracts, at the California Institute of Technology, the University of California, Chaney Laboratories, the National Bureau of Standards, and Beckman Instruments, Incorporated. Thus, experts in many fields—analytical methods, plant physiology, instrumentation, meteorology, and aerosols—focused their attention on the problem.

Another group delving into the problem was the Stanford Research Institute, which had been engaged by the Western Oil and Gas Association, representing about 200 California oil companies. There ensued a most extensive programme covering a period of five years and costing 1·25 million dollars (Stewart, 1953). This has resulted in the addition of a wealth of information on the air pollution problem (Stanford Research Institute).

While it is apparent that meteorological factors must play an important part in the accumulation and retention of the smogs, a careful study (Stanford Research Institute) failed to disclose any significant change in average temperatures, humidity, wind speed, total sunshine, or rainfall over a fifty-year period. Nevertheless, a temperature inversion exists above the city (and most of the county) during approximately 270 days each year (Magill and Littman, 1953). The height of these inversions varies between the surface and 3000ft. When the inversion descends below this level smog begins to be apparent, but only on fifty to seventy days a year does it become low enough to produce pronounced effects. The smog season is normally thought to be during the months of August, September, October and November, but during the winter season of 1953–54 there were many severe days during December and even in January.

A glance at the topographical map revealed that the area was hemmed in on three sides by mountains, with an open side toward the ocean. The local winds are usually of low velocity (averaging 5 m.p.h. during August, September and October) and are of a diurnal type, alternately blowing inland by day and out to sea by night, but seldom succeeding in cleansing the area of its accumulated pollutants.

Practically no coal is used in the county. Therefore fly-ash and soot are not local problems. There are more than 2,000,000 automobiles contributing their exhaust gases. They consume approximately 100,000 barrels, or over 4,000,000 gallons, of petrol per day. The Control District believes that the development of local areas of smog follows the ebb and flow of automobile traffic (Larson, unpublished). Waste disposal contributes considerable smoke, as there are fifty-five burning dumps and about a million individual backyard incinerators.

The county contains industrial plants of almost every description, but the public has come to believe that the petroleum refineries are largely responsible for the smog. In part, this belief is based upon the discovery by Haagen-Smit (1950) that hydrocarbons in the air could be oxidised to produce the compounds which would damage plants and cause eye irritation. The work was substantiated in experiments with control test chambers.

Studies indicated that during a smog the most characteristic chemical property was a strong oxidising action. After some fifty compounds had been tried in an effort to reproduce the typical damage on indicator plants, such as spinach, sugar beets, endive, alfalfa, and oats, success was achieved with the reaction products of ozone and unsaturated hydrocarbons. Maximum damage was found to occur with olefines of a chain length of five to six carbon atoms with the double bond in the end position. Petroleum fractions, boiling between 39 deg. and 69 deg. Cent., produced severe damage also.

The relation between severity of smog and cracking of rubber was also demonstrated (Haagen-Smit, 1950). Cracking of standardised rubber may be used as a sensitive index of ozone concentration. On smog-free days the normal cracking time is from forty to sixty minutes, indicating an ozone concentration of 0·02–0·03 parts per million. During severe smogs as much as 0·22 parts per million of ozone have been measured, corresponding to a cracking time of only six minutes. The effect, however, was not found at night.

Similar experiments using oxides of nitrogen, especially in the presence of sunlight, gave typical smog damage on plants as well as the characteristic smog odour and eye irritation.

The atmospheric oxidant is represented by a complex of factors consisting of atomic oxygen formed by the photochemical oxidation of organic material. The oxidant, by reacting with hydrocarbons and their oxidation products, produces peroxides and further degradation products. The peroxides or their radicals in turn play a part in the formation of ozone. Sulphur dioxide is believed to be oxidised to sulphur trioxide, contributing to the decrease in visibility. This change is catalysed by the presence of the nitrogen oxides which are released at the same time in combustion processes.

The investigating group at Stanford Research Institute does not accept Haagen-Smit's theory (Magill and Littman, 1953). Their experiments showed that saturated hydrocarbons did not increase the amount of ozone formed, whereas unsaturated hydrocarbons rapidly consumed the ozone. They consider that "the most likely explanation for the occcurrence of ozone near ground level is that it is formed as a result of reactions in the atmosphere brought about by the presence of sunlight and some as yet unidentified atmospheric impurities."

Although definite strides have been made during the five years of enforcement in Los Angeles County, the public reaction, as judged by the amount of local newspaper space devoted to the subject, indicates that the situation is worse. During the latter part of 1953 two deaths were reported to have been caused by smog, and the county medical society began a drive for an extensive research programme. Local business men joined in the formation of the Southern California Air Pollution Foundation.

In fairness to the efforts of the Control District, it should be pointed out that an estimated 600 tons per day of pollutants have been eliminated. There is no longer random burning at the fifty-five commercial and municipal dumps. Rigid control of the thirty-four ironfoundries has been achieved. Steel open-hearth and electric furnaces have been controlled at considerable cost and effort. Conversion to diesel-powered units of the major railways is now complete. There is less sulphur in the air than in the early 1920s. About 4,000,000 dollars will be spent within the next two years for control measures, including floating roofs or vapour recovery systems on petroleum storage tanks. Nevertheless, the autumn of 1953 was considered to have had some of the most severe smogs within memory.

Population growth is at the rate of 400 per day. Industry is growing apace. New refinery capacity planned for 1954 will boost output by 220,000 barrels per day. In December, 1953, a political crisis over air pollution developed, which has not yet been resolved. Out of it will probably come an effort at stricter enforcement, which may or may not result in more progress than is at present being made.

Canada

Canada is, in general, a sparsely populated country and except for certain industrialised areas most of which are situated near the American border, it has not been troubled with serious air pollution problems.

As early as 1913 the smoke problem was considered, as evidenced by the Fourth Annual Report of the Commission of Conservation (issued in Ottawa, 1913). Later came the investigations into the difficulties due to sulphur dioxide of the Trail (British Columbia) area, and into the Detroit-Windsor border problem by the International Joint Commission. Professor Allcut (1953) has collected information from forty-four of the larger population centres, of which seventeen have no by-law, eight passed by-laws before 1946, and thirteen did so after that date. Most of the by-laws had some clauses based upon the Ringelmann chart. A few limited the emission of dust and fly-ash to a maximum stack loading of 0·85 lb per 1000 lb of gases (adjusted to 12 per cent carbon dioxide). Other provisions of the by-laws called for smoke indicators, installation and operating permits, annual inspections, and set fees, and prohibited generally the emission of odours and noxious gases.

In 1949 the Committee on Atmospheric Pollution was appointed to study the problem and to draw up an example code to cover all air pollution. Recommendations were made for the organisation and powers of an air pollution control agency which could be adapted to local requirements.

Professor Allcut found no comprehensive studies available of air pollution in Canada, but presented a summary of the activities of the smoke abatement authorities of Toronto, Ontario. At present a survey of Toronto is being made, and will therefore be available for comparison with a similar study made in 1932–33.

The Trail problem is discussed elsewhere in this paper, but Professor Allcut calls attention to a similar situation in the Sudbury (Ontario) area, where approximately 40,000 to 50,000 tons of sulphuric acid are recovered annually from stack gases in nickel-copper smelting. However, it is believed (Katz, 1952*a*) that the annual emission of sulphur from the three smelters in the area may be as high as 1,000,000 tons and that other plants, now operating or under construction, have an additional capacity of 246,000 tons a year.

Poisoning of cattle and wild life, and human illness in the Yellowknife (Northwest Territory) area led to an investigation which found that the local roasters were emitting excessive amounts of arsenic trioxide. The study is continuing, and some control equipment has been installed. Unfortunately, the latter activity included the use of wet scrubbers, which resulted in a water pollution problem. Present efforts are being aimed at all elements of the environment—air, soil, water, and vegetation—in an attempt to ascertain allowable limits of contamination.

Professor Allcut points out that much of the smoke problem created by the transport industry is being resolved by conversion to diesel-powered units or substitution of liquid for solid fuels. While he regards this change as desirable as regards air pollution, he calls attention to the danger, in time of crisis, of almost total reliance on liquid fuels.

Professor Allcut also calls attention to an occurrence involving the new atomic energy industry, where a small leakage of radioactive material occurred at Chalk River (Ontario) in December, 1952. Ground level dispersion there is prevented by using high stacks, of from 450ft to 550ft in height.

For details and further information on Canadian activity in the field of air pollution, reference may be made to the paper by Allcut (1953), which has an extensive bibliography.

Technical Report

Road Research Technical Paper No. 15*:* "*Soil Survey Procedure.*" Second edition. H.M. Stationery Office. Price 1s. 9d.—The second edition sets out current views on the subject and emphasises the importance of mechanical boring, which has become more widely used in recent years. In the first edition the recommended method of conducting a soil survey was based mainly on the use of hand-augering, and tests other than those needed for the classification of soils were included as an integral part of the survey. In the present edition emphasis is placed on the value of mechanical augering, while the scope of the survey is confined to identifying the soils, establishing the soil profiles and examining the ground-water conditions. Tests to obtain other essential data on specific aspects of road construction, e.g. pavement design, are now regarded as more suitably forming the subject of separate investigations; they are described in other publications of the Road Research Laboratory. The opportunity has also been taken to expand the information concerned with the classification of soils.

Industrial and Labour Notes

Wage Claims and the National Economy

On Wednesday of last week, the National Joint Advisory Council met in London under the chairmanship of the Minister of Labour, Sir Walter Monckton, Q.C. One of the matters considered was the suggestion made by the Courts of Inquiry into the engineering and shipbuilding wage disputes that there should be set up "an authoritative and impartial body to consider the wider problems affecting the national economy."

It was explained to the council that the Courts of Inquiry, in putting forward the suggestion, had envisaged the appointment by the Government of a Royal Commission or a committee of comparable standing. The Courts thought that the functions of such a body should be to inquire into, and advise on, the wider economic problems which they had touched upon in their reports but with which they had felt themselves unable to deal conclusively ; and that it should be an *ad hoc* body, and not a standing committee, to inquire into the economic aspects of wage claims generally. The problems in question, in the Courts' view, related to rising production costs in their widest sense, and their impact on the national economy both domestically and so far as concerned the export trade. The proposed body, it was felt, should consider the whole question, not with a view to laying down rigid rules but rather with a view to giving general guidance based on sound economic principles. In order to ensure that its findings should have the greatest possibility of acceptance, the Courts of Inquiry thought that the suggested committee should be outside the sphere of political or official influence.

The Minister of Labour emphasised to the National Joint Advisory Council the importance of the issues raised by the Courts of Inquiry. He expressed the hope that the members of the Council would take a constructive view and that if they did not accept the suggestion, they would themselves put forward alternative proposals. During the discussion, the representatives of the British Employers' Confederation expressed the opinion that an inquiry on the lines suggested would be valuable and said that the Confederation would be prepared to co-operate fully if the Government decided to set up a committee. The representatives of the Trades Union Congress also said that they accepted the importance of the considerations to which the Courts of Inquiry had referred, and agreed that it was of the utmost importance that the facts and implications of the economic situation should be appreciated by all sections of the community. They considered, however, that no useful purpose would be served by setting up a committee such as that proposed. The T.U.C. felt that the "diversity of interests which must almost necessarily be represented on such a committee would probably result in majority and minority reports which would detract from the value of the inquiry, or in unanimous conclusions so watered down as to destroy the value of the unanimity." The principal view of the representatives of the nationalised industries appeared to be that there was a possibility of the reports of such a committee as that proposed being out of date before publication. They added that the committee would lack authority unless its conclusions were unanimous. But in spite of the difficulties, it was stated, if there was general agreement on the Council that such a body be set up, the nationalised industries would find it possible to assist.

Industrial Accident Prevention

Another matter considered last week by the National Joint Advisory Council was the development of further means of industrial accident prevention. It was stated that since the war accidents had been occurring at an annual rate of less than one per factory. But although during that period the accident rate had shown continuous decline, the fact remained that about one factory worker in every forty-eight suffered injury owing to accident during the year 1952, the total numbers being 471 killed and 154,995 injured. In addition, 321 workers were killed and 21,723 injured in 1952 in other places coming under the Factories Acts, such as docks, building and civil engineering sites, and warehouses.

After an examination of the existing means of promoting safety, the Council reached the general conclusion that a very large proportion of the accidents could not be prevented by law. The main hope for future reduction of the accident rate, it was thought, was along lines of co-operative effort by employers and workpeople to develop safety-mindedness and habits of safe working. The main practical questions were how to ensure that managerial responsibilities for safe working conditions and safe systems of work were effectively carried out ; that work people were properly instructed as to the cause of accidents and trained in the means of avoiding them ; and that the resources of the organisations of employers and trade unions were enlisted to encourage the co-operation of individuals in accident prevention. The Council decided that the matter was one which should be more fully considered by a sub-committee.

Trade Unions and Modern Management Methods

Last week-end, the British Institute of Management held its third Scottish conference at Gleneagles. One of the papers presented last Saturday was by Mr. James Crawford, the general president of the National Union of Boot and Shoe Operatives. It was entitled "The Attitude of Trade Unions Towards Modern Management Methods."

In the course of his paper, Mr. Crawford urged that co-operation and joint consultation were not merely desirable but were imperative if the best use was to be made of the technically intricate and costly plant and equipment and high standards of skill involved in present-day production. But, he said, technical efficiency was only the skeleton of industrial efficiency, and would look more presentable and acceptable after being "humanised" in the course of joint trade union and management discussions. Mr. Crawford went on to say that, in so far as good relationships depended on confidence and goodwill, nothing was more likely to destroy them than the suggestion or rumour that the introduction of new production processes, factory changes of one kind or another, or the use of work study and other techniques were to be considered and determined solely by management. Despite a small minority of voices, Mr. Crawford continued, trade unions recognised that management must manage and make final decisions. That was a responsibility which included "taking into account anything the work people's representatives might wish to say about changes or developments, and a willingness to negotiate if necessary on related wages and working conditions."

Talking about problems of time study, Mr. Crawford said that trade unions were increasingly recognising that time study could serve a useful purpose in industry provided it was used honestly and that its limitations were appreciated. Trade union opposition to time study would be greatest where management insisted that the technique eliminated the need for collective bargaining and that it provided a mathematically correct answer to wage and work load problems.

Trade with Russia

On Thursday of last week, the thirty-eighth annual general meeting of the Russo-British Chamber of Commerce was held in London. The Chamber is affiliated to the Association of British Chambers of Commerce, its object being the promotion of trade between the British Empire and the U.S.S.R. Sir Greville Maginness is president of the Chamber. In the course of his address at the meeting last week, Sir Greville referred to the orders placed by Soviet importing organisations this year with firms in this country, amounting to a value of between £30,000,000 and £40,000,000. These, he said, included some substantial orders for trawlers, textile machinery, rolling mill plant, milk bottling machinery, machine tools, woodworking machinery, generating sets, switchgear and other electrical equipment, power cables and several other items of industrial equipment. The encouraging volume of orders already placed, Sir Greville remarked, had been much facilitated by the visits made by British business men to Moscow in recent months. That, he added, was the best method of approach, for direct contacts between buyer and seller were the only satisfactory way of concluding negotiations and thereby establishing good relations.

A.E.U. and Wage Stability

This week the national committee of the Amalgamated Engineering Union is holding its annual conference at Blackpool. The conference began on Monday morning with an address by the president, Mr. Robert Openshaw, who suggested that joint efforts could be made to bring about a period of wage stability.

In the course of his address Mr. Openshaw recalled that in the concluding stages of the negotiations on the recent wage claim, the employers' representatives had expressed a wish that the engineering industry could have a period free from the disruption of new wage claims. To that, Mr. Openshaw said, he would not be averse. He appreciated the difficulties, he continued, of contracting for orders with the uncertainty that before the contract was completed the price might have to be altered, possibly more than once, on account of wage increases. But, Mr. Openshaw added, if the employers were entitled to stability so were the members of the A.E.U.

Mr. Openshaw then went on to say that there was no reason why the employers of this country, through the Federation of British Industries, should not, jointly with the Trades Union Congress, approach the Government with proposals to keep down and even reduce prices ; or why the employers' organisations themselves could not take steps to prevent the cost of living continually rising by voluntary schemes for the stabilisation of prices. Given an attitude of determination to hold prices to the consumer steady, Mr. Openshaw commented, the unions could feel much happier about exercising restraint in their demands.

Changes in Wage Rates

The Ministry of Labour has reported that changes in wage rates which came into operation in the United Kingdom during March resulted in increases aggregating approximately £180,000 in the weekly full-time wages of about 690,000 workpeople. Those receiving increases included workpeople employed in the motor vehicle retail and repairing trade, operating staff in municipal tramway, trolleybus and omnibus undertakings, and company-owned omnibus undertakings. Workers employed in the electrical contracting industry, a section of the heavy chemicals industry, and in the ferrous and non-ferrous scrap industries also received increases. The Ministry says that in the first three months of this year changes in wage rates resulted in increases aggregating £821,100 in the weekly full-time wages of 3,401,000 workers. In the comparable months of last year there was a net increase of £873,000 in the weekly wages of 2,921,000 workers.

Industrial Production

The Central Statistical Office of the Treasury has announced that the index number of industrial production (1948=100) in February has been estimated provisionally at 130 for all industries, compared with a revised figure of 127 for January. Figures for the comparable months of 1953 were 122 in February and 118 in January. Taking the manufacturing industries only, the index for February this year has been estimated at 133, compared with 123 a year earlier, while that for mining and quarrying has been put at 118, compared with 116 in February last year. The Treasury says that, according to information so far received, the index for all industries in March may be expected to be 132 or 133.

Notes and Memoranda

Air and Water

INSHORE MINESWEEPER.—The inshore minesweeper, H.M.S. " Warmingham," was launched from the Hampton boat yard on the River Thames of John I. Thornycroft and Co., Ltd. The ship has a length of 106ft 5in and a beam of 20ft 6in.

LLOYD'S WRECK RETURNS.—Lloyd's Register of Shipping has issued its returns of merchant ships totally lost, broken up, &c., during the quarter ended September 30, 1953. The world total of steamships and motorships lost consequent upon casualty amounted to forty-four ships of 45,847 tons gross and included two ships of 558 tons owned in Great Britain and Northern Ireland and nine ships of 1441 tons gross owned by the other Commonwealth countries. Of the steamships and motorships lost not consequent upon casualty, thirty-four ships of 130,843 tons gross were owned in Great Britain and Northern Ireland and seven ships of 25,413 tons by the Commonwealth countries forming part of the world total of ninety-three ships of 293,325 tons gross.

Miscellanea

MR. PHILLIP WARD.—We record with regret the death of Mr. Phillip T. Ward, which occurred on April 29th, in Sheffield, following a long illness, at the early age of thirty-five. Mr. Ward, who was the son of Mr. Ashley S. Ward, was a director of Thos. W. Ward, Ltd., which he joined in 1937. He was also a director of Birchley Rolling Mills, Ltd., Darlington Railway Plant and Foundry Company, Ltd., and John Williams (Wishaw), Ltd. For the greater part of the second world war Mr. Ward served with R.A.F. Fighter Command.

REVISION OF B.S. 891 : DIRECT READING HARDNESS TESTING (ROCKWELL PRINCIPLE).—A B.S.I. committee is at present engaged in the revision of B.S. 891 : 1940, " Direct Reading Hardness Testing (Rockwell Principle)." In order that present-day practice may be recognised in this revision, the committee would be grateful for any information on the extent to which Rockwell scales other than A, B or C are now in use Letters should bear the reference MEE/37/9/1 and be sent direct to the British Standards Institution, 2, Park Street, London, W.1.

SINGLE STACK PLUMBING.—As a result of an investigation by the Building Research Station and full-scale trials by the London County Council, it has been shown that a worthwhile saving can be made in the cost of plumbing in multi-storey flats. In the new system—the single stack system—all venting is eliminated for flats up to five storeys. Above five storeys, or when the stack is to serve more than one flat per floor, some venting is needed. The single stack system, the Building Research Station states, is safe and efficient, provided that certain simple design rules are followed. The saving of the new system is estimated at 40 per cent for five-storey flats.

ALUMINIUM-MAGNESIUM ALLOY.—We have received from Foundry Services, Ltd., Long Acre, Nechells, Birmingham, 7, a copy of Information Sheet No. 33, which is concerned with the aluminium-magnesium alloy to British Standard 1490—L.M. 10. The sheet gives the properties of the alloy and casting characteristics, deals with such matters as melting procedure and casting temperatures, and then goes on to discuss moulding technique. Information is given about sand properties, metal/mould reaction, and the effect of additions of beryllium, while notes are included upon running and gating methods and also upon running and feeding methods.

WORK STUDY CONFERENCE.—The British Institute of Management has announced that, in co-operation with the British Productivity Council, it is holding a work study conference at Harrogate from May 27th to 29th. The conference is being organised round the work study developments carried out by Imperial Chemical Industries, Ltd. The programme is designed to give top management a fuller understanding of work study, and with a view to relating general principles to the circumstances obtaining in different trades and processes. The Minister of Labour, Sir Walter Monckton, Q.C., has promised to address the conference on Friday evening, May 28th.

OIL CONSUMPTION.—The Petroleum Information Bureau has published statistics of the United Kingdom's oil consumption in 1953 on behalf of the United Kingdom Industry Advisory Committee. The returns show that consumption, exclusive of bunkers for ships engaged in foreign trade, totalled 19,002,695 tons compared with 17,510,285 tons in 1952, and of the total 5,739,955 tons represented motor spirit and 5,532,465 tons gas, diesel and fuel oils. Last year the home refineries produced a total of 25,395,959 tons against 22,490,363 tons in 1953, with fuel oil at 10,747,120 tons being the largest single product, while the biggest increase occurred in motor and aviation spirit, which increased from 4,935,418 tons in 1952 to 6,243,355 tons.

SUMMER COURSE ON HEAT TRANSFER.—The Loughborough College of Technology announces that its Department of Chemical Engineering has made arrangements for a short vacation course on Heat Transfer during the period July 19th to 31st inclusive. Following the precedent of the previous two courses in 1952 and 1953, this course will be mainly of a practical nature. To obtain the maximum benefit from the course a student should have some knowledge of heat transfer, but it is anticipated that there may be many wishing to attend the course whose knowledge of the theory and practice of heat transfer is either in need of revision or is largely non-existent. For these, the first few days of the course will be spent largely in the lecture room discussing the special introductory notes previously issued to students. Thereafter the course will take the general form of morning lecture on a special topic or aspect of heat transfer, followed for the remainder of the day by carrying out experiments on such pilot-scale apparatus as heat exchangers, jacketed pan coolers, heaters, drying and humidification plant, &c., according to a further set of specially prepared laboratory notes. The inclusive fee for the course is twenty guineas, but for students living locally who would not require accommodation in hall of residence or mid-day meals, the fee will be twelve guineas. The number of students attending is limited to thirty.

EASTER SCHOOL FOR HEADMASTERS AND SCIENCE MASTERS.—An easter school for headmasters and science masters was held by Metropolitan-Vickers Electrical Company, Ltd., at its Trafford Park works from April 21st to 23rd. It was organised to provide opportunities for masters in the public schools and grammar schools to see at first hand the industrial applications of the principles of science, and to observe how these young men are prepared for responsible employment either by entering industry direct from school for combined practical and theoretical training, or through completion of a degree course and graduate apprenticeship. The school was attended by some eighteen headmasters and eighty-eight science masters and by representatives of the Ministry of Education and the Education Departments of the Institutions of Mechanical and Electrical Engineers. The arrangements included talks on and visits to several manufacturing departments of the factory, the company's research department and the apprentice training school, and provided opportunities for discussing problems of mutual interest.

COKE PRICE INCREASES.—Some comments about increases in coke prices have been made by the Joint Iron Council, which represents the producers of foundry pig iron and the ironfounding industry. The Council points out that the price increases in coal announced by the National Coal Board on April 14th include increases in the price of coal used for making coke, and that the ironfounding industry will be heavily hit by the coking coal price rise. It will suffer both through its use of pig iron (embodying higher charges for the blast-furnace coke) and of coke used for its own melting purposes. The Council goes on to say that the public should be warned that serious effects will be inevitable as a result of the sharp upward movement of coke prices. These effects will make themselves felt almost immediately. Categories concerned will be building materials made of iron, iron goods for public utility services, motor vehicles and nearly the whole range of engineering products, which embody many iron castings. Higher costs for iron castings, it is argued, could exert a depressing influence upon the competitive efforts of the engineering industry in the export markets. The Joint Iron Council expresses the view that these price increases are not justified, either as regards coal in general or coking coal in particular. It says that " the whole question of the National Coal Board's policy in further increasing the price of coal, with dangerous consequences to industry and perhaps to employment, should be thoroughly and critically examined on the floor of the House of Commons."

Contracts

THE ISLES OF SCILLY STEAMSHIP COMPANY has placed an order with John I. Thornycroft and Co., Ltd., to build a cargo and passenger ship to replace the " Scillonian." The ship will have an overall length of 208ft by 30ft beam and a draught of 10ft, and will be propelled at a speed of 15·5 knots by two oil engines developing a total of 1340 b.h.p.

STEWARTS AND LLOYDS, Ltd., has received a contract for over 350 miles of 16in seamless pipe from the Sui Gas Transmission Company, Pakistan. The order involves a quantity of over 40,000 tons and the value exceeds £2,000,000. It is stated that shipments of pipe to Karachi will begin in about a month's time and the whole of the order will be supplied from the contractor's seamless mill in Scotland.

THE BRITISH ELECTRICITY AUTHORITY has placed contracts during the past month for power stations, transforming stations and transmission lines amounting in the aggregate to £11,027,990. The principal contracts include :—Brunswick Wharf power station, Poplar, high and low-pressure pipework and valves (C. A. Parsons and Co., Ltd.), and 132kV, 66kV, 33kV and auxiliary cables (W. T. Glover and Co., Ltd.) ; Deptford East power station, London, 66kV switchgear (Metropolitan-Vickers Electrical Company, Ltd.) ; Goldington power station, Bedford, 132kV, 2500MVA switchgear (A. Reyrolle and Co., Ltd.) ; Castle Donington power station, near Derby, two 830,000 lb per hour boilers (Babcock and Wilcox, Ltd.) ; Nottingham power station, Ash and dust-handling plant (B.V.C. Industrial Constructions, Ltd.) ; Willington A power station, near Derby, Four circulating water pumps (Drysdale and Co., Ltd.) ; Hams Hall C power station, near Birmingham, 132kV and auxiliary cables (W. T. Glover and Co., Ltd.) ; Carmarthen Bay power station, Burry Port, 132kV switch house (Balfour Beatty and Co., Ltd.) ; Connah's Quay power station, near Flint, 3000V and 415V auxiliary switchgear (A. Reyrolle and Co., Ltd.) ; Keadby power station, Scunthorpe, high and low-pressure pipework (C. A. Parsons and Co., Ltd.) ; Stella North power station, near Newcastle upon Tyne, reinforced concrete cooling tower (Davenport Engineering Company, Ltd.) ; Chadderton power station, Oldham, chimney (P. C. Richardson and Co. (Middlesbrough), Ltd.) ; Huncoat power station, Accrington, superstructure (William Moss and Sons, Ltd.) ; Clyde's Mill power station, Glasgow, four 180,000 lb per hour boilers (Yarrow and Co., Ltd.) ; Dalmarnock power station, Glasgow, six 200,000 lb per hour boilers (Yarrow and Co., Ltd.) ; Iver substation, Bucks, site works (J. L. Kier and Co., Ltd.) ; Monk Fryston substation, Yorks, site and foundation works (M. Harrison and Co. (Leeds), Ltd.) ; Penwortham substation, near Preston, site and foundation works (J. Gerrard and Sons, Ltd.) ; Windscale substation, Yorks, 132kV, 2500MVA switchgear (Metropolitan-Vickers Electrical Company, Ltd.) ; Hunshelf substation, Yorks, 132kV and 66kV connections and ancillary equipment (A. Reyrolle and Co., Ltd.) ; Carlton Husthwaite substation, Yorks, two 15MVA, 132/11kV transformers and earthing transformers (Bruce Peebles and Co., Ltd.) ; Spondon-Allerton-Winster, 132kV overhead line (Balfour Beatty and Co., Ltd.) ; Drakelow power station-Burton power station, 132kV overhead line (Balfour Beatty and Co., Ltd.) ; Creyke Beck-Driffield, Yorks, 132kV overhead lines (Riley and Neate, Ltd.), and Rochdale, Lancs, 132kV overhead line (British Insulated Callender's Construction Company, Ltd.).

Personal and Business

MR. JOHN CREEK has been appointed Sales Director of Fibreglass, Ltd., St. Helens, Lancs.

MR. E. F. JOHNSON has been appointed sales manager of Cimex-Fraser Tuson, Ltd., Orpington, Kent.

MR. J. C. CUNNINGHAM has been appointed public relations officer of Percival Aircraft, Ltd., Luton.

MR. D. A. THOMSON has been appointed to the board of The Belmos Company, Ltd., Bellshill, Lanarkshire.

MR. HENRY S. WINGATE has been elected president of The International Nickel Company of Canada, Ltd.

HIGH PRESSURE COMPONENTS, Ltd., Hampton, Middlesex, has been acquired by Mr. H. W. Bowen, M.I.Mech.E.

COLONEL B. H. LEESON, M.I.E.E., has been re-elected chairman of the Association of Short Circuit Testing Authorities.

MR. B. THORNTON has resigned his directorship of the Wellman Smith Owen Engineering Corporation, Ltd., for reasons of ill-health.

MR. C. GILLAM has been appointed chief engineer in the communications division of Marconi's Wireless Telegraph Company, Ltd.

W. CANNING AND CO., Ltd., states that its Sheffield office is to be moved, on June 1st, to 1, South Parade, Shalesmoor, Sheffield, 3.

NEWMAN INDUSTRIES, Ltd., Yate, Bristol, states that Mr. W. D. Wilson, general manager of the Grantham works, has been appointed a director.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., announces the appointment of Mr. A. J. Budd as assistant superintendent at the Leonard Works.

JOHN HARPER AND CO., Ltd. Willenhall Staffs., announces the appointment of Mr. H. Moore as foundry sales representative in the London area.

THE INSTITUTION OF PRODUCTION ENGINEERS announces that its address is now 10, Chesterfield Street, London, W.1. Telephone number, Grosvenor 5254/9.

EDWARD WILCOX AND CO., Ltd., Manchester, has opened a London office at Fulwood House, Fulwood Place, Holborn, W.C.1 (telephone, Chancery 2206).

MR. M. M. HALLETT has been appointed director of research of Sheepbridge Stokes, Ltd., Sheepbridge Equipment, Ltd., and Sheepbridge Steel Castings, Ltd.

MR. GABRIEL P. CLAY, M.I.Mech.E., chief engineer of Metals Division, Imperial Chemical Industries, Ltd., has been appointed to the board of the Metals Division.

MACROME, Ltd., Aldersley, Wolverhampton, announces the appointment of Mr. J. S. Dick as Scottish area manager, with headquarters at 11, Bothwell Street, Glasgow, C.2.

GOODENOUGH PUMPS, Ltd., is the title of the company hitherto known as Goodenough Contractors Machinery, Ltd. Its works continue at 70–72, London Road, Twickenham, Middlesex.

MR. W. H. ALLEN has relinquished his appointment with Messrs. Preece, Cardew and Rider to become production engineer to the Bermuda Electric Light Company, Ltd., Pembroke, Bermuda.

ELGAR MACHINE TOOL COMPANY, Ltd., Hanworth, Middlesex, has been appointed sole agent in the United Kingdom for Pfeifer of Heilbronn, Traub of Reichenbach-Fils, and Heinemann of St. Georgen/Schwarzwald.

THE BURNTISLAND SHIPBUILDING COMPANY, Ltd., announces that having reached the age of retirement, Mr. W. E. Douthwaite has relinquished his appointments as a director and assistant managing director of the company.

J. STONE AND CO., Ltd., Deptford, London, S.E.14, has purchased the engineering interests of Chance Brothers, Ltd., Smethwick. A new company is to be formed, which will be called Stone-Chance, Ltd., with Mr. Bryan Preston, deputy chairman of J. Stone (Holdings), Ltd., as chairman, and Mr. John Raymond, hitherto managing director of Chance Brothers, Ltd., as managing director. Chance Brothers, Ltd., will continue to manufacture its glass products.

British Patent Specifications

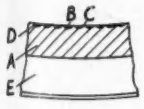
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

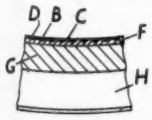
Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

BEARINGS AND SUPPORTS

706,264. August 21, 1951.—JOURNAL BEARINGS, The English Electric Company, Ltd., Queen's House, 28, Kingsway, London, W.C.2. (*Inventor: James Millar Smith.*)

The invention relates to journal bearings of a comparatively hard load-carrying material with a comparatively soft material of good anti-friction properties embedded in recesses of its surface. Such bearings are suitable for heavy loads and high speeds in diesel engines. Referring to the upper view of the drawing, the bronze shell *A* has crescent-shaped grooves *B* machined into its inner surface. The width of the groove is about four times the width of the ridges *C* between them. The grooves are filled with anti-friction metal *D* by electrolytic deposition, and then the bearing is machined to size so that narrow strips of bronze alternate with wide strips of anti-friction metal. A thin coating of anti-friction metal is then deposited on the finished bearing surface, including the bronze strips. The flanges at the end of the shell are shown at *E*. Referring now to the lower view, the grooves *B* filled with anti-friction metal *D* are provided in the bronze liner *F* backed by steel bush *G* having end flanges *H*. In a strip type bearing also shown in the specification the grooves filled with anti-friction metal are provided in the strip of harder metal by machining or by pressing, either in the shaped shell or in the flat strip before forming. This strip has no flanges and is located by a dowel. The initial uniform covering of soft anti-friction metal deforms under the high loadings imposed on the bearing in accordance with the underlying support and, therefore, the wear is greater in the anti-friction metal over the ridges of hard metal than over the axial grooves. Since the grooving is substantially axial and, therefore, normal to the movement of the journal, the soft bearing metal in the grooves under plastic deformation spreads out as a thin film of low frictional properties over the ridges of harder metal preventing the exposure of that metal, and, in time, the bearing surface may conform to a series of narrow inclined planes favourable to the development of high load carrying oil films.—*March* 24, 1954.



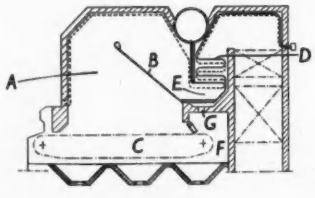


No. 706,264

STEAM GENERATORS

706,975. August 28, 1950.—TUBULAR STEAM GENERATORS, Heinrich Vorkauf, responsible partner of La Mont Kessel Herpen and Co., Kommanditgesellschaft, Geibelstrasse 14, Hanover, Germany.

The invention consists in a method of improving the combustion in combustion chambers of comparatively small height according to which the products of combustion are first led upwards and subsequently downwards by means of a tube wall formed by closely spaced tubes through which boiler water is passed by forced circulation and that the velocity of the products of combustion on their way up as well as on their way down is continuously increased. The drawing shows a forced boiler with a travelling grate stoker. In the combustion chamber *A* a wall *B* composed of closely spaced tubes rises towards the front diagonally. The gases rising from the grate *C* are accelerated through the reduction in the cross section and are forced into the upper corner of the combustion chamber. From this point the gases flow downwards, with increasing velocity. Before they pass over the convection heating surfaces *D* the gases are once again diverted. In this way the comparatively high velocity at the end of the downward flow is utilised for the separation of impurities through centrifugal force in the diversion space *E*. The lower part of the diversion space is connected with a space *F* at the rear of the grate by an opening *G* that can be closed; thus the separated ash can be emptied periodically from an ash hopper formed at the bottom of the space *E*, into the space *F*. The wall *B* also enables good use to be made of all parts of the combustion chamber, with very little dead area. It is also an advantage that the flue gases pass over the horizontal heating surface *D* from below, as in this case the heating surfaces do not become fouled so easily. The steam drum can be arranged so low that it comes under the boiler roof. In this way dead corners are avoided. Modified arrangements for a forced circulation steam generator with hand-fired stokers are also shown in the specification.—*April* 7, 1954.

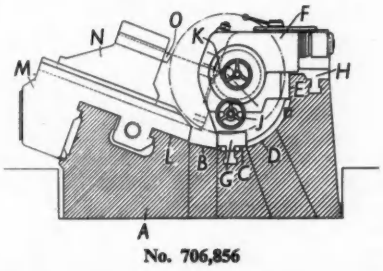


No. 706,975

MACHINE TOOLS

706,856. May 28, 1951.—IMPROVEMENTS TO LATHES, Oskar Waldrich, Werthenbach, Kreis Siegen, Germany.

The invention is concerned with the further development of the lathe disclosed in the parent specification, No. 618,146. According to it the bed in the parent specification is modified in that it has a surface contour of which the saddle or carriage-guiding way no longer defines a horizontal plane, but a plane which is inclined and, as seen from the operating side, slopes downwards towards the back, while the adjoining part extends substantially cylindrically about the work piece axis over an angle of at least 90 deg. As in the parent specification, the tailstock has its two limbs supported on the front and back respectively of the cylindrical part of the bed. The lathe bed *A* shown in the drawing has an upper surface the parts *B*, *C*, *D* and *E* which together present a substantially cylindrical contour which extends over about 120 deg. On these parts the tailstock *F* is supported by its limbs *G* and *H* which are at 90 deg. to one another and are clamped by the aid of T-slots. A handwheel operates a tailstock hydraulic locking system. The tailstock centre indicated in dotted lines at *K* is eccentric with respect to the tailstock barrel. From the contoured part *B* to *E* a section of the bed extends in the form of a plane part *L* which serves for guiding the longitudinally moving carriage *M*, on which a cross slide *N* is mounted in the usual way. In the drawing there is no top slide, the tool *O* being mounted directly on the cross slide. The tailstock operating mechanism is fully described in the specification.—*April* 7, 1954.

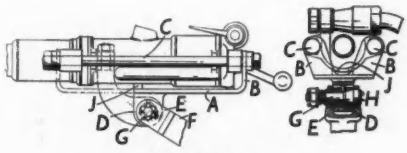


No. 706,856

TOOLS AND WORKSHOP APPLIANCES

706,946. December 18, 1951.—THE MOUNTING OF PORTABLE DRILLING MACHINES, Huwood Components, Ltd., Glasshouse Street, St. Peters, Newcastle upon Tyne, 6. (*Inventor: George Andrew McLeman.*)

Referring to the drawings, the drilling machine bracket *A* comprises a strip of steel having at one end two bifurcated vertical portions *B* which are bored to receive the ends of the side rods *C*. At the other end the bracket has a boss *D* which fits between a bifurcated boss *E* at the upper end of a telescopic member *F* of the feed mechanism, on which the bracket is mounted by a pivot pin *G*, and its general construction will be seen from the drawing. A resilient pad *J* is arranged on the inner portion of the bracket *A* above the boss *D*, on which the body of the machine rests. It will be seen that the length of the bracket *A* imparts a resilience so that the vibration of the machine is substantially damped by the time it arrives at the upper end *F* of the telescopic feed member. An alternative form is also shown in the specification.—*April* 7, 1954.

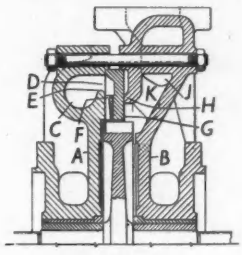


No. 706,946

TURBINES AND PUMPS

706,973. July 11, 1950.—TURBINES AND CENTRIFUGAL PUMPS, National Research Development Corporation, 1, Tilney Street, London, W.1. (*Inventors: Ulrich Max Willi Barske and Walter Muller.*)

As the drawing shows, two stator members *A* and *B* of the turbine are secured together by bolts. In the first or inlet stator member *A* an annular fluid inlet chamber *C* of substantially circular cross section has a continuous annular exit port *D*, lying in a plane normal to the axis of the turbine of radial width approximately equal to half the diameter of the chamber. The inner edge *E* of the port is rounded to allow the fluid an unrestricted passage through it as it passes into the nozzles *F* of an annular nozzle ring *G* on its way to the rotor. The ring is pressed against the annular faces bounding the port by an annular rib *H*, formed on the second stator member *B* and having a radial width approximately equal to half the radial width of the port. When the stator is assembled the action of the bolts in drawing the parts together applies an axial thrust to the nozzle ring. The rib *H* forms part of the exhaust chamber *J* and it is supported by stiffening webs *K* integral with the chamber.—*April* 7*th*, 1954.

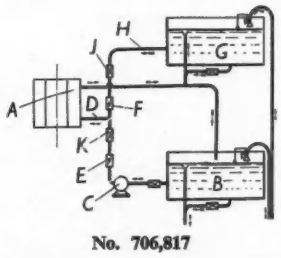


No. 706,973

METALLURGY

706,817. March 14, 1952.—COOLING DEVICE FOR CHILL MOULDS, Gebr. Böhler and Co., Aktiengesellschaft, Elisabethstrasse 12, Vienna 1, Austria.

The cooling of chill moulds for continuous elongated castings, more particularly by means of water, has to be very accurately supervised during the casting. Tests have shown that a very short interruption in the flow of the cooling medium causes the wall of the chill mould to burn through at once, whereby the whole of the installation is stopped for days. It is therefore necessary to take steps to prevent any failure in the flow of the cooling medium. The device according to the invention is illustrated in the drawing. The cooling medium is supplied to the cooling jacket *A* of the chill mould from the container *B* by the pump *C*, through the pipe *D*, past the non-return valve *E*. If the pump pressure drops, the non-return valve *F* opens and liquid flows to the jacket from the highly placed container *G* through the pipe *H*. Reducing valves *J* and *K* are incorporated in the pipes *H* and *D* in order to be able to adjust exactly the amount of the flow.—*April* 7, 1954.



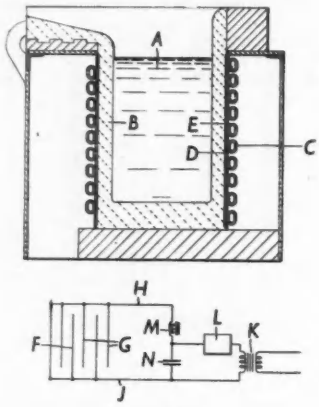
No. 706,817

ELECTRICAL ENGINEERING

704,960. November 1, 1950.—ELECTRIC INDUCTION FURNACES, Henry Wiggin and Co., Ltd., a British company, Sunderland House, Curzon Street, London, W.1. (*Inventor: Harry Thomas Kempson.*)

In electric induction furnaces used for melting metals there is a risk of the lining of the furnace being damaged with the result that the molten metal may come into contact with the coil by which the heat is generated. According to the invention the conductors of the furnace are incorporated in a flexible screen of heat-resisting material which is interposed between the induction coil and the lining of the furnace. In the furnace shown in the drawing the metal *A* is melted in a cavity with a resistant lining *B*. The metal *A*, is heated by eddy currents produced in it by an induction coil *C*. This coil is protected by a screen *D* surrounding the lining *B* and separated from the coil by mica insulation *E*. The screen is a mat woven of vertical wires and horizontal asbestos

threads. The distance between adjacent wires is about ¼in. The wires *F* and *G* (lower diagram) alternate and are connected to two busbars *H* and *J*. These busbars are connected in the alarm circuit as shown in the lower view. Power is supplied to this circuit through a transformer *K* and when any



No. 704,960

molten metal penetrates through the lining *B* of the furnace and forms a bridge between one of the wires *G* and one of the wires *H*, then a current flows and energises an alarm *L*. Normally, however, there is no connection between the wires *G* and *H* and any high-frequency currents induced in the wires by the coil *C* are filtered out by a choke *M* and condenser *N* so that the alarm is unaffected by them. A cut-out for the high-frequency current may also be operated by the alarm circuit.—*March* 3, 1954.

706,543. July 28, 1952.—ROTORS FOR SMALL ELECTRIC MOTORS, Siemens-Schuckertwerke Aktiengesellschaft, 1, Berlin-Siemensstadt, Berlin and Erlangen, Germany.

According to the invention there is provided a rotor, produced from metal powder by sintering, for use in electric motors, more especially small alternating current synchronous motors. It consists of a mixture of ferromagnetic and non-magnetic metals. Normally the proportion between the magnetic metal and the non-magnetic metal is regular over the entire volume. In some cases, however, it may be advantageous to make the content of non-magnetic metal higher in some zones, for example in the neighbourhood of the external periphery of the rotor. There is thus produced within the structure of ferromagnetic metal a more or less continuous phase of non-magnetic metal which forms a short-circuited winding and, for example, acts in the manner of a starting winding in the case of small synchronous motors.—*March* 31, 1954.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

RAILWAY SIGNALLING SYMBOLS: PT. II, WIRING SYMBOLS AND WRITTEN CIRCUITS

No. 376 : 1954. Price 12s. 6d.—The revision of Part I of this British Standard, "Schematic Symbols," was published in 1951. The publication of the revision of Part II now brings this British Standard up to date. It includes railway signalling symbols for wiring diagrams and written circuits and also explains a system of labelling wires whereby each wire can be readily identified with that shown on the circuit diagram. Notes and recommendations on the nomenclature for wiring diagrams, written circuits and the labelling of wires are included, together with examples of common combinations. The symbols included in the standard are for railway signalling systems and are not intended for power lines, commercial electrical engineering machinery or telecommunications.

LETTER SYMBOLS, SIGNS AND ABBREVIATIONS: PART I, GENERAL

No. 1991 : 1954. Price 6s. Confusion frequently results from the use by authors of different systems of symbols, signs and abbreviations in similar or related branches of science and technology.

When it was decided to revise two well-established and partly overlapping British Standards, viz., B.S. 560 : 1934, "Engineering Symbols and Abbreviations," and B.S. 813 : 1938, "Chemical Symbols and Abbreviations," it was thought desirable to take the opportunity of combining them so as to remove unnecessary conflict and pave the way to the development of a consistent system for the whole field.

As B.S. 560 covered such specialised subjects as "locomotive classification," "naval architecture" and "hydraulics and water engineering," the B.S.I. committee entrusted with the work decided that, in the first instance, attention should be focused on the more fundamental quantities of common concern to all branches of pure and applied science, on conventions relating to their use, and on abbreviations for relevant words, especially the names of unit. B.S. 1991 : 1954 : Part I, General, is the outcome of this decision, and it will be left to groups of experts in specialised fields to build in various directions on the foundations thus laid.

It is recognised that the attainment of a reasonable measure of agreement will entail the abandonment of a few practices that are well established in certain fields of work, but it is believed that the sacrifice is worth making. Departures from well-established usages are recommended, however, only where they are considered to be of serious importance, e.g. the abandonment by mechanical engineers (in particular) of the symbol ϕ for entropy, which is commonly represented by *S* by physicists and chemists throughout the world, as well as by most engineers in other countries. Indeed, it is strongly urged that recommendations of symbols for thermodynamic quantities should be strictly followed, for these quantities are widely used by workers in practically every branch of science and technology, and incomplete agreement on the symbols allocated to them has hitherto been one of the major sources of confusion.

It should be noted that besides providing recommendations for a wide, but by no means complete range of quantities, the standard is intended to give guidance towards the development of a general system. It urges that the general principles put forward should be accepted and followed rather than that there should be rigid adherence in all instances to recommendations on the use of individual symbols or abbreviations. In particular, there should be no departure from the consistent use of italic (sloping) type for symbols for physical quantities (whether the letters are capitals or lower case), and of roman (upright) type for most other purposes such as abbreviations for words, including the names of units.

In the present revision and combination of the more fundamental factors of the two British Standards, full account has been taken of the recommendations of the Royal Society Symbols Committee and of the reports issued from time to time by such international bodies as the International Electrotechnical Commission, the International Union of Pure and Applied Chemistry and the International Union of Pure and Applied Physics.

Launches and Trial Trips

LONDON PRESTIGE, oil tanker; built by the Furness Shipbuilding Company, Ltd., for London and Overseas Freighters, Ltd.; length between perpendiculars 560ft, breadth moulded 80ft, depth moulded 42ft 3in, deadweight 24,600 tons on 32ft 3½in summer draught; twenty-seven cargo oil tanks, two pump rooms, four 500 tons per hour Duplex steam oil cargo pumps, two stripping pumps, steam deck machinery; two 75kW steam-driven generators; N.E.M.-Doxford single-acting, two-stroke oil engine, six cylinders 670mm diameter by 2320mm combined stroke, 6800 b.h.p. at 119 r.p.m., steam for auxiliaries at 150 lb per square inch supplied by one Scotch boiler and one Foster Wheeler "D" pattern water-tube boiler.—Trial, April 20th.

PERLIS, cargo ship; built by the Caledon Shipbuilding and Engineering Company, Ltd., for the Straits Steamship Company, Ltd.; length between perpendiculars 195ft, breadth moulded 40ft, depth moulded to upper deck 19ft, deadweight 725 tons on 9ft 6in draught; trial speed 10 knots; six passengers; two cargo holds, four 3-ton, two 5-ton and one 10-ton derricks, electric deck machinery; three 75kW diesel-driven generators; Ruston and Hornsby supercharged, four-stroke, single-acting, diesel engine, eight cylinders, 573 b.h.p. at 500 r.p.m.—Launch, April 21st.

NYMPHE, cargo ship; built by the Furness Shipbuilding Company, Ltd., for the Compania Armadora Transoceania S.A.; length between perpendiculars 435ft, breadth moulded 59ft, depth moulded to upper deck 39ft 2in, deadweight 10,000 tons on 26ft summer draught; five cargo holds, fifteen derricks ranging from 2 tons to 30 tons, electric deck machinery, one diesel-driven and two steam-driven 150kW generators; N.E.M.-Doxford single-acting, two-stroke oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4400 b.h.p. at 115 r.p.m., three "Nelvin" vertical thimble-tube boilers.—Launch, April 21st.

PATHFINDER, survey ship; built by J. Samuel White and Co., Ltd., to the order of the Crown Agents for the Colonies for the Government of Nigeria; length overall 162ft, length between perpendiculars 150ft, breadth moulded 27ft 6in, depth moulded 12ft; draught loaded 10ft, deadweight 340 tons, trial speed with 175 tons deadweight 11·5 knots; two 20kW steam-driven generators; machinery supplied by Plenty and Son, Ltd.; two triple expansion steam reciprocating engines, cylinders 10·5in, 17·5in and 27·5in diameter by 18in stroke, each engine 350 i.h.p. at 150 r.p.m.; one cylindrical boiler, 200 lb per square inch working pressure.—Trial, April.

BRITISH CHANCELLOR, oil tanker; built by the Blythswood Shipbuilding Company, Ltd., for the British Tanker Company, Ltd.; length 515ft, breadth 69ft 6in, depth 37ft 6in, deadweight 16,000 tons; twenty-seven cargo oil tanks, two cargo oil pump rooms, four 500 tons per hour oil cargo pumps; Barclay Curle-Doxford two-stroke oil engine, six cylinders 670mm diameter by 2320mm combined stroke, 6900 b.h.p.; two oil-fired auxiliary Scotch boilers.—Launch, April 21st.

DUNDEE, cargo ship; built by the Burntisland Shipbuilding Company, Ltd., for the Dundee, Perth and London Shipping Company, Ltd.; length between perpendiculars 251ft, breadth moulded 43ft, depth moulded to shelter deck 29ft 2in; draught loaded 18ft 11in, deadweight 2900 tons, speed 11 knots; six passengers; two main cargo holds, six 3-ton and two 10-ton derricks, hydraulically driven winches; British Polar diesel engine, nine cylinders 340mm diameter by 570mm stroke, 1640 b.h.p., three 90kW diesel-driven generators.—Trial, April.

BRITISH ENGINEER, oil tanker; built by Harland and Wolff, Ltd., Belfast, for the British Tanker Company, Ltd.; length overall 665ft, length between perpendiculars 630ft, breadth moulded 85ft 6in, depth moulded 46ft 8in, deadweight 32,000 tons; thirty cargo oil tanks, one cargo oil pump room; two 600kW turbine-driven alternators, one 150kW diesel-driven alternator; one set of Harland and Wolff compound, double reduction geared turbines, 12,500 s.h.p. in service at 112 r.p.m. of propeller; steam supplied at 450 lb per square inch and 750 deg. Fah. by two oil-fired Babcock and Wilcox integral furnace water-tube boilers.—Trial, April 30th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to held should be clearly stated.*

COMBUSTION ENGINEERING ASSOCIATION

To-day, May 7th.—Grand Hotel, Harrogate, Annual Conference.

INSTITUTE OF MARINE ENGINEERS

Tues., May 11th.—85, Minories, London, E.C.3, "The Free-Piston Gas-Generator Turbine as a Power Plant for Ship Propulsion," F. A. I. Muntz and Robert Huber, 5.30 p.m.

Mon., May 17th.—85, Minories, London, E.C.3, Films, "Power for Ships," and "Diesel Power on the River Thames," 6.30 p.m.

INSTITUTE OF NAVIGATION

Fri., May 21st.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Visual Aids to Bad-Weather Approach," E. S. Calvert, 5 p.m.

INSTITUTE OF PETROLEUM

Fri., May 14th.—26, Portland Place, London, W.1, Symposium on Medical Services in the Petroleum Industry, 5.30 p.m.

Wed., May 19th.—Manson House, 26, Portland Place, London, W.1, "Medical Services in the Petroleum Industry," S. D. McClean and F. L. Webster, 5.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

To-day, May 7th.—Holland, Joint Conference on "Unit Processes of Oxidation," with the Koninklijk Institute van Ingenieurs, the Chemical Section of the Netherlands Chemical Society and the Chemical Engineering Group of the Society of Chemical Industry.

INSTITUTION OF CIVIL ENGINEERS

Tues., May 11th.—RAILWAY MEETING: Great George Street, Westminster, London, S.W.1, "Wear of Steel Rails: a Review of the Factors Involved," J. Dearden, 5.30 p.m.

Thurs., May 13th.—MIDLANDS ASSOCIATION: James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, 5.30 p.m.——N.W. ASSOCIATION: Engineers' Club, Albert Square, Manchester, Annual General Meeting, Film Show, 6.30 p.m.

Tues., May 18th.—STRUCTURAL AND BUILDING MEETING: Great George Street, London, S.W.1, "Design and Construction of the Superstructure of the Marshal Carmona Bridge at Vila Franca de Xvia, Portugal," T. J. Upstone and W. Cardno, 5.30 p.m.

Thurs., May 20th.—ROAD MEETING: Great George Street, London, S.W.1, "The Road Surface as a Factor in Street Lighting," A. W. Christie, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Tues., May 11th.—MEASUREMENTS SECTION: Savoy Place, London, W.C.2, "Measurement as a Factor in Understanding," K. J. R. Wilkinson, 5.30 p.m.

Thurs., May 13th.—UTILIZATION SECTION: Savoy Place, London, W.C.2, "Fuel Supplies of the Future," E. F. Schumacher, 5.30 p.m.

Mon., May 17th.—LONDON STUDENTS' SECTION: Savoy Place, London, W.C.2, Annual General Meeting, Film Show, 6.30 p.m.

Tues., May 18th.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Questions Night, 6 p.m.

Thurs., May 20th.—ANNUAL GENERAL MEETING: Savoy Place, London, W.C.2, Corporate Members and Associates only, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, May 7th.—GENERAL MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, "The Accountancy Service to Works Management," C. E. Power, 5.30 p.m.——S. WALES BRANCH: Mackworth Hotel, Swansea, "Combustion in Compression-Ignition Oil Engines," S. J. Davies, 6 p.m.

Fri., May 14th.—GENERAL MEETING, STEAM GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Rapid Starting Technique: Some Significant Tests at Poole Power Station," J. S. Hall and A. F. Britton, 5.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Tues., May 11th.—BIRMINGHAM GRADUATE SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, 3, "Work Study and the Production Engineer," R. Guthrie, 7 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., May 20th.—Royal Institution, Albemarle Street, London, W.1, Wilbur Wright Memorial Lecture, "The Choice of Power Units for Civil Aeroplanes," A. E. Russell, 6 p.m.